Responses of Bell Peppers (*Capsicum annum* L.) to Excision of Initial Flowers and Fruits and Fertilization with Nitrogen and Calcium

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TO MY FATHER, MOTHER AND WIFE

WHO HAVE RENDERED GREAT PATIENCE AND DEVOTION

THIS DISSERTATION IS HUMBLY DEDICATED WITH AFFECTION

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INTRODUCTION

Peppers (Capsicum annum L.) are grown as a fresh vegetable throughout the United States, but are more extensively grown in the south. Florida, the greatest producer (Table 1), grows and ships about one-third of the green peppers used by the United States markets (168). Peppers are considered as Florida's seventh most important vegetable crop in terms of value (28). The acreage and production of peppers in Florida in 1960 was about six times the volume of the 1921 crop.

Peppers are employed both as a fresh vegetable and as a condiment. In this country large thick-fleshed or non-pungent (Bell pepper) varieties are widely used in salads or are stuffed with meat and cooked.

Many cultural problems are related to this important crop and little attention has been given in the past toward their solutions. Some work has been done on the fertilization of peppers with nitrogen, phosphorus and potash (118, 122, 123, 124, 125, 128) and the materials such as calcium and magnesium (130, 131) in south Florida. Geraldson (59, 60) has shown the relationship between calcium availability and blossom-end rot of peppers. This was confirmed by the experiments of Ozaki and Ozaki (130, 131). In central Florida, work has been reported by Jamison (80) on nitrogen and magnesium fertilization and fertilizer placement with peppers.

TABLE 1

GREEN PEPPERS FOR FRESH MARKET: ACREAGE, PRODUCTION AND FARM VALUE--1960

State	Acreage for harvest (Acres)	Production (1,000 cwt.)	Value (1,000 Dollars)
Florida	13,200	1,221	12,881
New Jersey	8,200	492	2,312
North Carolina	5,200	192	1,267
California	4,500	698	4,707
Texas	3,800	247	2,371
Louisiana	1,800	54	421
Ohio	1,400	133	705
Virginia	1,400	28	105
Connecticut	750	52	328
Massachusetts	700	52	276
Mississippi	650	15	140
Rhode Island	150	11	56
All states	41,750	3,195	25,570

Source: U.S.D.A., Crop Reporting Board. Vegetables-Fresh Market, Annual Summary of Acreage, Production and Value. Washington, D. C. 1960.

One of the existing problems with peppers is a stunting of plant growth on the sandy soils. This is particularly true with winter-grown peppers in south Florida where low yield of fruits with undesirable shape and size generally is obtained from stunted plants. The causes of this serious stunting are not known. It is perhaps important to maintain a level of soil fertility which will allow the plants to grow rapidly after seeding or transplanting to produce a plant of moderate size prior to blooming and subsequent fruit-setting.

The present investigation was conducted with the following objectives:

(1) to determine if early deflowering and defruiting will have any effect on the growth of the plants and yield and quality of pepper fruits;

(2) to determine the optimum levels of nitrogen and calcium to obtain maximum growth and fruit yields under the conditions of the experiments;

(3) to test the varietal differences of growth and fruiting of peppers;

(4) to evaluate suitable chemical means of deflowering and defruiting applicable to large scale pepper production; and

(5) to add to the information available on blossom-end rot and sunburning of peppers in relation to the above mentioned factors.

REVIEW OF LITERATURE

Effect of Deflowering and Defruiting on Growth and Development

As early as 1899, a series of most interesting results of the removal of flowers on the growth and development of Vicia faba was reported by Mattirolo (97) using 53 and 54 plants in his treated and check plots, respectively. He found that normal plants usually dried up after the fruit matured, while plants from which flowers had been removed daily showed an excessive growth of all organs, roots, stems, shoots, leaves, flowers and nodules continuing past the normal season of the plants. It was very interesting to note that during the period of fruit development the tubercles disappeared, reappearing after fruiting was over. Records on chemical analysis revealed that the nodules of the check plants were more or less empty and contained 4.58 per cent nitrogen, while those of the treated plants were hard and had 6.71 per cent nitrogen.

Studies on flower removal on the growth and absorption of soil nutrients by various field crop plants were made by Egoroff (50) and Taranovsky (159). The observations showed that while some plants did not seem to respond greatly to deflowering, the majority were affected conspicuously in growth and development. When fruits and seeds were not permitted to develop on the plants the following major physiological changes were observed:

(1) A marked increase in development of all vegetative parts, including the roots.

(2) A higher osmotic pressure of the cell sap.

(3) A greater assimilation of carbon dioxide.

(4) An increase in absorption of soil nutrients.

(5) A higher total production of dry matter.

(6) Deflowered plants seemed to better utilize the environment in comparison with undeflowered ones.

Heckel (69), by analysis of corn and sorghum at different periods after deflowering, found that the removal of female flowers in corn caused increases in the sucrose but little change in the reducing sugars. Again, a small change in the sugar content of plants was effected by removing the male flowers. When only the flower parts were removed, there was an increase in the non-reducing sugars of the sorghum.

Cotton plants which showed marked effects of fruit development on growth, have attracted the attention of a number of workers in agronomic experiments. Extensive statistical records on growth and development of Egyptian cotton have been made by Harland (64) and Balls (13) who showed that vegetative growth decreases at the same time as, and in inverse proportion to, the number of flowers and fruits present. These results were explained as being due to environmental factors, particularly to a severe water strain and the resultant accumulation of toxins in the meristematic regions.

Working with the Sea Island cotton Mason (95) observed a striking retardation in the growth of both the central stem and lateral branches

coincident with the flower formation and fruit development. The rate of elongation of the central axis decreased at the time of floral development in exact proportion to the number of flowers formed and the number of fruits set. With the cessation of growth, there was a marked shedding of immature flowers, and in older plants even a conspicuous dropping of young fruits. The suggestion was made that the senescence of the central axis of the cotton plants is associated with paucity of carbohydrates and possible "other growth-promoting substances" as a result of their translocation to the basal fruiting branches. The shedding of young fruits and flowers was likewise explained and fertilization was assumed to be operative in some manner as a causal factor stimulating the movements of assimilates into the fruit.

Ewing (53) noted that toward the end of the fruiting season of cotton vegetative growth and flowering ceased--all the energy of the plant apparently being utilized in the development of the fruit. When most of the fruit had attained a mature stage rejuvenescence was shown by the appearance of new flowers and fruits. Removal of the flowers at the time of shedding caused an increase in the size of the plants and doubled the number of flowers per plant. In some conditions of extreme great moisture and fertility, growth and flowering were found to be continuous.

There is considerable evidence to suggest a correlation between blossom development and leaf area. Chandler and Heinicke (30) reported a tendency for grapevines to have a relatively greater leaf area when

blossoms were removed. Murneek (106) found the growth of Bonny Best tomato plants greatly increased as a result of blossom removal.

Several investigators have studied the relation of leaf area to carbohydrate accumulation. Magness and Overley (94) found that an increased number of leaves per apple resulted in an increase in size of fruit and in fruit bud formation. Aldrich (3) emphasized the effects of a comparatively larger leaf area per fruit on carbohydrate reserves while Potter and his associates (140) working with Oldenberg apple trees, found that the average spur leaf area of trees completely deflowered to be considerably larger than that of spurs from trees on which 50 per cent of the spurs were allowed to blossom. Struckmeyer and Roberts (155) found larger leaves and more blossom buds due to deflowering treatment in apple trees. According to Thies (163), the average increase in leaf area as a result of deflowering in McIntosh apple was found to be about 35 per cent. The work of Bailey (12) indicated the necessity of removing about 90 per cent of the apple blossoms to insure development of the fruit buds for the following season.

Davis (43) was able to prove that deflowering and defruiting had considerable effect on the blossom bud differentiation in sugar prune.

Lachman (87) studied some effects of blossom removal on the vegetative development in determinate type tomato plants. He reported that the fruit size was more uniform when only one fruit cluster was left. Total yields were significantly greater when one, two and three fruits per cluster were left than from any other treatment during the three years of the experiment. According to Watts (174), removal of late

clusters of flowers resulted in increased early and total yields and increased the size of fruits, but did not advance the date of the first harvest in Marglobe variety of tomato grown under controlled conditions in a greenhouse. He concluded that under conditions where late season yields are of little value and in which plants are not extremely vigorous, the removal of the late cluster of blooms might be worthwhile.

Recently, Miller (103) working with Fireball tomatoes, reported that deflowered plants gave significantly higher total early yield and larger fruits than undeflowered plants.

Using Scarlet Dawn variety of tomato, Horsfall and Heuberger (78) found that defruiting caused an increased amount of foliage and their data indicated a fairly general relation between fruit load and vegetative growth.

Wolf and Hartman (178) increased fruit set in hand-pollinated muskmelon flowers with various types of pruning by removing fruits. According to Brantley and Warren (25), removal of two or three fruits per plant until three weeks before the harvest increased the average size of melons but had no significant effect on yield. Removal of all perfect flowers at anthesis greatly increased the number of perfect flowers produced and in general, the increases were progressively larger as the amount of nitrogen was increased. Similar results were obtained with the number of fruit set when the developing fruits were removed.

Watson and Petrie (172), while studying distribution and redistribution of nitrogen within tobacco reported a much greater accumulation

and a smaller net loss of nitrogen from leaves of plants in which inflorescence was removed.

Okra plants harvested every three to four days produced three times as many pods as did plants on which the pods were allowed to mature. Seed formation caused a severe check in plant growth (66, 137). According to McAlister and Krober (98), 80 per cent depodding reduced seed yield but increased weight per seed, stem yield, sugars, starch, and nitrogen in leaves and stems. Depodding increased seed protein but decreased the oil content and iodine number in soybeans.

Effect of Chemicals on Deflowering and Defruiting

Little work has been done on chemical deflowering and defruiting which is directly concerned with the present problem. However, it seems worthwhile to review some of the literature regarding the flower and fruit thinning by chemicals.

Auchter and Roberts (9) were first to demonstrate that chemical sprays could be used effectively to thin apple flowers. From their work there has evolved the use of toxic substances such as phenols and cresols to kill some of the blossoms. Burkholder and McCown (24) were the first to find that an auxin such as naphthaleneacetic acid (NAA) could be effectively used to thin flowers. Subsequent workers have found that auxins are effectively used in thinning of young fruits as well.

The thinning of flowers and fruits by auxins, as listed by Leopold (89), appears to be function of three physiological factors:

(1) the thinning of flowers by prevention of natural pollination;

(2) the abortion of young embryos and a subsequent dropping of the fruits; and

(3) the direct forming of abscission the alteration of the auxin gradient at the abscission zone.

Evidence has indicated that auxins may alter the germination and growth of pollen tubes. For example, in synthetic medium Addicott (1) obtained a small inhibition of pollen tube growth with indoleacetic acid (IAA), and a greater inhibition of pollen germination.

In studies by means of which auxins may thin apple flowers, Luckwill (92) treated flowers with various concentrations of NAA and subsequently introduced fresh pollen on the stigmas. The inhibition of the pollen germination following the auxin treatment was remarkable. This action of auxin in thinning will of course apply only to flowers (156).

The ability of auxin to cause the abortion of embryos in young fruits was first demonstrated by Swanson, et al. (158) in Tradescantia fruits. In apple thinning by auxins, Murneek (109) noted that the abscissed fruits uniformly contained aborted embryos whereas the fruits remaining on the tree contained a large proportion of normal embryos. Since endosperm was the most conspicuous tissue showing the deterioration in the abscissed fruits he proposed that thinning action was a consequence of the abortion of the endosperm or perhaps of the inhibition of the normal embryo growth. According to Luckwill (92) endosperm is the principal source of auxin to the young apple fruit and deprived of its auxin supply, the fruit would be expected to abscisse. In

olives, Hartman (65) has found that application of auxin to the fruit was ineffective in thinning whereas application of the auxin to the foliage of the tree resulted in the shedding of fruits. Auxins were ineffective for thinning of peach flowers when there was no foliage. Approximately two or three weeks after the bloom when the foliage had developed on the trees, auxin sprays could be effectively used to thin the fruits (72).

Another auxin 2,4,5-trichlorophenoxyacetic acid has been used successfully for thinning Anjou pears (61) but comparative trials with various auxins on other fruits indicated that NAA was the best for thinning (65).

The sodium salt of NAA has been most generally used in auxin fruit thinning work. The reason is not clear but the auxin is certainly effective and the sodium salt is convenient in that its solubility is much greater than that of the free acid. While most treatments are made by means of an aqueous spray, dust preparations have been used with good success (92).

The use of chemicals in inducing the male sterility is getting wide attention. Sodium 2,3-dichloroisobutyrate (FW-450) is of special interest to the plant breeders. Hensz and Mohr (71) were able to completely eliminate the open staminate flowers in watermelon with concentrations of 0.25 and 0.5 per cent. While working on lettuce Foster and Murdock (57) did not find any development of anthers following the treatment with FW-450. Pate and Duncan (136) have made the extensive studies with FW-450 on cotton crop. Significant results were obtained in the induction of male sterility and the gametocide was reported to

be phytotoxic at very high concentrations. Recently, Scott (147) while working with the mechanism and reversal of sodium 2,2-dichloropropionate (Dalapon) and FW-450, reported that the exogenous application of these gametocides to cotton plants induces nondehiscent anthers.

Gibberellic acid, a plant growth substance has been most extensively used during the last five years on plant responses. According to Biggs (18), gibberellic acid accelerated abscission over a wide range of concentrations, from 10^{-8}M to 10^{-3}M. The degree of promotion by gibberellic acid was less than NAA in explants. However, the controlling influence of gibberellic acid on naturally occuring abscission was not determined. Addicott (2), in experiments with excised material reported that gibberellin accelerated abscission markedly when applied close to the abscission zone.

General Nutrition of Peppers

Sand and loam soils are generally preferred for the production of peppers. Soils that are not naturally fertile need the addition of manures or green manures and commercial fertilizers for maximum production of good quality peppers.

Boswell, et al. (22) have reported that peppers require little more nitrogen and potash than tomatoes. On loam and heavier soils of fair to good fertility, 500 to 600 pounds of fertilizer per acre, containing 4 to 5 per cent nitrogen (N), 6 to 8 per cent potash (K_2O) should be thoroughly mixed with soil along the rows about a week

before transplanting. Later when the plants have set several fruits, 150 pounds of nitrate of soda or 100 pounds of ammonium nitrate or 125 pounds of ammonium sulfate should be applied per acre as a side dressing near the rows and cultivated into the soil. On light sandy soils, 750 to 1,000 pounds per acre of a 5-8-8 or 5-10-10 fertilizer should be worked into the soil before transplanting time and a side dressing with 150 pounds of nitrate of soda with an addition of 50 pounds of muriate or sulfate of potash should be done at the time of fruit set (15, 23).

According to the recommendation of the Agricultural Extension Service of the University of Florida (170), experience has shown that 1,900 pounds of 6-8-6 fertilizer should be applied on the light sands in Florida, and 1,000 pounds per acre of the same fertilizer on the dark sand. In addition two to three side dressings of nitrogen and potash at the rate equivalent to 100 pounds nitrate of soda and 25 pounds of muriate of potash per acre are generally needed for the growing period in Florida (81).

In Louisiana, it has been recommended by Cox, et al. (41) that about two weeks before transplanting 800 pounds of 4-12-4 per acre should be applied in a drill and well mixed in the ridge of the row. Nitrate of soda should be used for top dressing at the rate of 100 pounds per acre, making the first application when the plants begin to set fruit and the second application about a month later.

Cochran (32, 34), working with pimentoes in Georgia, reported that in order to supply the necessary amount of plant nutrients, a 4-8-8

fertilizer mixture should be applied at the rate of 600 to 800 pounds per acre in the row before planting and the plants side-dressed twice with 150 to 200 pounds of a 14-0-14 fertilizer per acre. On lighter, sandy soils of south Georgia, Dempsey and Brantley (44) found that 1,000 to 1,200 pounds per acre of 4-8-8 fertilizer with two side dressings of 14-0-14 at the rate of 100 to 200 pounds per acre was sufficient to obtain maximum yields and later it was recommended (35, 152).

Under the growing conditions of Hawaii, Nakagawa (113) has reported that 500 pounds per acre of 10-10-5 or 8-20-5 fertilizer is sufficient at the time of transplanting. A month after transplanting a second application of fertilizer consisting of 500 pounds per acre of 3:1 mixture of amophos (11-48-0) and sulfate of potash (10-0-50) should be used in fields low in both phosphate and potash. On the fields showing high phosphate and potash levels, sulfate of ammonia at the rate of 250 pounds per acre is sufficient. Additional applications of 200 pounds per acre of sulfate of ammonia a month after the second application and every month thereafter until the end of the crop should be made to increase the vigor and size of fruits.

As early as 1926, Lloyd (90), in Illinois in his pepper culture tests, indicated that neither the use of nitrogen in the form of nitrate of soda nor of phosphorus in the form of bone meal resulted in any consistent increases in the yield of peppers. He also concluded that treatment with nitrate of soda in addition to irrigation seemed detrimental to yield under Illinois conditions.

The chief fertilizer for pepper growing in New Jersey, as reported by Nissley (116), is a commercial mixture of 5-10-10 averaging 1,200 to

2,000 pounds per acre applied in various ways whereas the same mixture for Bell peppers in North Carolina (14) is used at the rate of 800-1,000 pounds per acre applied a week before transplanting. The remainder of the fertilizer is applied as side dressing two or three times with 10 to 15 pounds of nitrogen at two to three week intervals.

According to a report of Queensland Department of Agriculture (141) a common commercial fertilizer mixture for sweet pepper growing in Australia is one containing 4.5 per cent N, 13.5 per cent P_2O_5, and 5 per cent K_2O at the rate of 600 pounds per acre with additional side dressings of sulfate of ammonia 200 pounds per acre. In South Africa, 20 tons of stable manure and 500 pounds of superphosphate per acre prior to planting plus side-dressing application of ammonium sulfate at the rate of 200 to 400 pounds per acre have been reported to be adequate for pepper growing (162).

In a preliminary study Taylor and Dobson (161) observed that development of bacterial spot in peppers was affected by rates of fertilization. With treatments ranging from 0 to 10,000 pounds per acre of 12-12-12 equivalent it was indicated that bacterial spot incidence decreased as fertilizer rates increased to 5,000 pounds per acre.

According to Downes, et al. (47), early yield of bare-rooted plants were almost doubled by using 10-50-10 starter solution. However, yields from transplanted plants grown in bands were not increased by the use of a starter solution at transplanting. Use of starter solution did not increase total yields. At about the same time Parker and

Bailey (133) in Georgia reported that all starter treatments tested increased total yield and all, except ammonium nitrate, promoted early maturity. From this test it was concluded that increased yields from the use of starter solution were due to a great number of fruits being produced rather than to an increase in weight or size of fruits. Similar results were reported by Parker and Bailey (134) in subsequent experiments.

Transplanting solutions, as reported by Lachman, et al. (88) were quite effective in encouraging a quick replacement of roots and in stimulating early growth of pepper plants. A greater early yield of pepper fruits was obtained due to the interaction of clay pots and transplanting solutions. According to Miller (100) soluble fertilizer (10-52-17) as a starter solution increased early yields but decreased late yield of pepper fruits.

Two factorial experiments on the fertilization of peppers were conducted by Ozaki, et al. (124, 125) and it was found that application of phosphorus above 100 pounds per acre did not increase yields or height of plants in either experiments. Ozaki and Ozaki (128), while studying the mineral uptake of pepper plants on Davie fine sand reported that a single application of P_2O_5 at 200 pounds per acre and minor elements resulted in yields of peppers comparable to those obtained from plants which received a second application of P_2O_5 at the rate of 200 pounds per acre and minor elements.

In fertilizer experiments by Dolan and Christopher (45), pepper yield data revealed an increased yield at the high (5-15-5) phosphorus

treatment over low (5-5-5) treatment. As reported by Rudizinska (145) fertilization with 18 per cent superphosphate at the rate of 0.5 grams per pot accelerated blossoming and fruit formation and increased total yields of several pepper varieties.

According to Ozaki, et al. (124), each increment of potash from 100 to 300 pounds per acre produced taller plants. There was an interaction between nitrogen and potash levels. When both nitrogen and potash were applied at 100 or 120 pound rates, the plants were of normal green color. However, when the potash was increased to the 200 or 240 pound rates with low nitrogen levels, the plants were yellowish green. The yield response of nitrogen and potash were also interrelated. At the low potash (100 pounds K_2O) no response to nitrogen was obtained. However, at the high potash level (300 pounds K_2O) each increment of nitrogen resulted in significant yield increases.

Bi-weekly applications of 30 to 40 pounds per acre of K_2O for a total of 300 pounds during the season produced highest yields of marketable peppers, as indicated by Ozaki and Ozaki (127), Ozaki and Ray (126) and Ozaki, et al. (125). However a reduction in the yield was obtained at the rate of 400 pounds per acre of K_2O (127).

Significant increases in the yield and quality of pepper fruits were obtained by raising the K_2O levels from 100 to 200 pounds per acre. Uptake of potassium by the plant was increased with the increased rates of applied potash. Potassium content of the fruit was increased by the higher potassium levels (124, 125). A linear increase in the yield of pepper fruit was obtained brom bi-weekly applications of potash as

sulfates of potash ranging from 20 to 40 pounds per acre from the second crop after the frost injury (122).

Bjornseth (19) reported that in Michigan pepper seedlings were injured at the time of pricking off by an excess or deficiency of nitrate and potassium in the soil. Pepper plant satisfactory for field setting could be grown at a nitrate level varying from 25 to 35 ppm and a potassium level varying from 15 to 35 ppm in the soil. It was concluded that more rapid growth could be obtained by growing pepper plants at a lower level of nitrate and potassium and then supplementing with nitrate and potassium fertilizers in solution later in the growing period when the needs of the plants are greater.

According to Dolan and Christopher (45), a 50 per cent reduction of potash (from 5-10-7 to 5-10-3.5) significantly reduced the yield of peppers.

In experiments by Ozaki (121), pepper yields were increased by raising the rate of bi-weekly 10-0-10 fertilizer applications from 200 to 300 pounds per acre in a commercial field. In a recent report Ozaki (122) stated that an interaction was found between fertilizer and variety. Increasing the bi-weekly side-dressings of 10-0-10 from 300 to 350 pounds per acre increased Florida Giant fruit yields but decreased World Beater yields.

Cochran and Olson (36, 37), working on the monthly absorption of nutrients from the soil by pimento pepper plants, reported that at the end of the first month in the field, the entire acre of the pimento pepper plants absorbed from the soil less than one-half pound of nitrogen

and phosphoric acid, and even smaller amounts of potash, calcium and magnesium. The absorption of nutrients during the second month was small but there was an increase over the absorption for the first month. The largest quantity of nutrient was absorbed during the third month. Nitrogen, calcium, potassium, magnesium and phosphorus followed in this respective order as to quantity absorbed. Although phosphorus was absorbed least of any, it was possible that rather large quantities should be included in the fertilizer mixture because of rather high phosphate fixing capacity of some of the soils which made some of the phosphate unavailable to the growing plant.

Addition of nitrogenous fertilizers, unbalanced phosphoric acid and potash fertilizers resulted in much diminished vitamin C content whereas a complete fertilizer resulted in an increased vitamin C content of peppers (138).

Jamison (80) reported that pepper yields were decreased by the addition of magnesium to the fertilizer in which the nitrogen was used in the form of nitrate of soda. On the other hand magnesium used with ammonium sulfate appeared to have a beneficial effect on the growth and yield of peppers.

Relationship of Nitrogen to Plant Growth and Fruiting Responses

Plant growth probably is limited more often by a deficiency of nitrogen than of any other nutrient. Of the various nutrient elements commonly applied to the soil, nitrogen is the most abundant in nature.

Most plants derive their supply of nitrogen from forms in the soil. Soils and plants have a particularly intimate relationship with respect to nitrogen since the building up of the supply of soil nitrogen, on which most plants are dependent, itself has resulted from the growth of plants (20, 74, 102, 153).

As a constituent of protoplasm, nitrogen is intimately involved in the activity of every living cell. Moreover, excess or deficiencies of nitrogen quickly affect the characteristics of plant tissues and growth. For example, an excess of nitrogen results in a stimulation of vegetative growth which may result in delayed maturity and in extreme cases in a decrease in the fruitfulness because of the dropping of flower buds (5, 29, 144).

A deficiency of nitrogen results in a lighter green color of the foliage and further nitrogen starvation gives rise to the limited development of chlorophyll, thus the yellow pigments are in evidence and the plants turn lighter green or yellow depending upon intensity of the nitrogen deficiency (20, 68, 102). The element is subject to translocation in plant and hence there is a movement from the older plant parts to the point where new tissues are being formed. The result is a yellowing of the older tissues or leaves. If the deficiency continues, the older leaves may become dry and drop off (6, 149).

Stunting of the top growth of plants is frequently the result of a nitrogen shortage, but oddly, roots are elongated according to Heald (68) and Cochran (33). Ozaki and Hamilton (118) described a bronzing condition of pepper leaves, followed by necrosis and leaf drop which was

associated with high nitrogen additions to the soil. Miller (100, 101), working with Bell peppers, reported that nitrogen deficiency was characterized by stunted weak growth and chlorotic leaves. Fruits produced under nitrogen deficient condition were somewhat chlorotic, although they would have been salable from a color standpoint. Fruits produced on high nitrogen plants were short, thick, somewhat rounded in shape and were glossy dark green in color.

Various authors in their reviews on plant nutrition have pointed out that both source and concentration of nitrogen in the substrate will have profound effect on the cation content of the plant tissues (8, 115, 143, 179). It has been shown by Burris (29) that increasing the proportion of nitrate to ammonium nitrogen in the substrate increases the production of organic acids, particularly oxalic acid. Because oxalic acid precipitates much of the absorbed calcium, plant growing under high nitrate levels may utilize more calcium (8, 105).

According to Hoffman (75), a greater percentage of flower bud abscissed before anthesis with nitrogen deficiency than with carbohydrate deficiency in pepper plants. Eguchi, et al. (49) reported that flower bud initiation of pepper was considerably delayed in pots without nitrogen. According to Madras Pepper Research Scheme of Indian Council of Agricultural Research (7), phosphorus and potassium did not increase yield in the absence of nitrogen, and 60 pounds nitrogen instead of 40 pounds per acre increased yield only in the presence of phosphorus and potash.

Cochran (31) reported that in general pepper plants that received a relatively high nitrogen treatment set significantly higher percentage of blooms than did plants receiving low nitrogen. The increase in fruit set resulting from frequent applications of nitrate of soda was in agreement with Murneek's results in tomato (107) and with Werner's (175) in eggplants and peppers. Lloyd (90), however, found that applications of nitrate of soda in addition to irrigation was detrimental to fruit setting in peppers. This was accounted for, most likely, by the fact that combination treatment disrupted the carbohydrate nitrogen balance within the plant, a condition which was shown by Kraus and Kraybill (85), Nightingale (115) and by Watts (173) to influence greatly the fruit set in tomato.

According to Ozaki, et al. (117), increase in the level of nitrogen from 120 to 240 pounds per acre showed a significant increase but reduced the yield at the highest level (360 pounds per acre). Intensity of foliage color was increased by increasing the level of nitrogen.

Total marketable yield of peppers were not significantly influenced by increasing the bi-weekly rate of nitrogen application from 20 to 40 pounds per acre. However, increasing the rate of nitrogen application resulted in increasing the incidence of blossom-end rot and in decreasing the incidence of sunburning (100, 101, 126, 128).

Ozaki and Hamilton (118), while studying the effect of nitrogen on the yield and quality of sweet peppers, reported the significant increase in the yield and quality by the application of 200 pounds per acre of nitrogen as compared to 100 pounds per acre. The nitrogen content of

the leaves increased with each increment of nitrogen. In a similar experiment on nitrogen fertilization Ozaki and Ozaki (130) reported a linear reduction of the early yields for the first three pickings. In another experiment (129) nitrogen sources of anhydrous ammonia and ammonium nitrate had no significant differences on the yield of peppers. Ozaki and Ray (126) did not find any significant differences in U.S. Fancy pepper yields between inorganic and organic sources of nitrogen, a result similar to Ozaki (121) and Miller (100).

According to Dolan and Christopher (45), side dressing with nitrogen during the growing season helped to maintain the proportion of nitrogen for proper balance of nutrients. Ozaki (122) reported that after frost injury to the pepper plants a bi-weekly application of 30 pounds nitrogen per acre as ammonium nitrate produced a larger second crop than application of 20 or 40 pounds per acre.

Relationship of Calcium to Plant Growth and Fruiting Responses

Not only does calcium affect soil properties such as soil colloids, soil pH, and microbiological activities which have an influence on plant growth but the element serves as a nutrient itself. In addition, calcium has much to do with the availability and absorption by the plant of several other nutrient elements.

Next to potassium, calcium is the most abundant basic element in plants. However, compared to potassium content the calcium content of

most crop plants is quite low. In discussing the average calcium content of plants it should be borne in mind that the percentage of calcium in different specimens of a given plant species is by no means uniform. In fact, it will vary widely with the quantity of available calcium in the soil. For example, Smith and Hester (150) found the calcium content of cabbage to increase from 4.42 per cent to 7.40 per cent as a result of the application of lime. Other factors than liming may influence the calcium content of plants. Danniel and Harper (42) found the calcium content of several species of grasses and alfalfa to increase under low moisture conditions and to decrease when effective moisture supply increased.

Although the presence of calcium is essential for the normal development of plants, the quantity of the element required by different plants varies considerably. An adequate supply of calcium appears to stimulate the development of root hairs and in fact the entire root system (105). The element is necessary for normal leaf development and tends to accumulate in the leaves as well as in the older parts of plants such as the bark (17, 39, 40, 54, 165).

The abundance of calcium in leaves may be due to presence of calcium pectate in the middle lamella. The element may also protect the plant against accumulations of oxalic acid by neutralizing it and when a deficiency of calcium exists, various substances such as aluminum and manganese may accumulate in plants in harmful concentrations (16, 20, 102, 167).

In general deficiency of calcium causes rapid and quite spectacular disintegration of the terminal growing parts of shoot and root in many species of plants. This is a symptom which develops first as a malformation of the younger leaves (20, 149). In peppers, Miller (100, 101) observed no terminal dieback but plants tested with low calcium solutions were stunted and had very dark green color of leaves. There was substantial reduction of calcium in vegetative portions of plants that were treated with either low or very low calcium or high levels of nitrogen and potash.

Studies with radioactive calcium showed that calcium contents of the upper leaves of cucumber plants were about the same whether the plants had received a large or small amounts of calcium, but that former plants were healthy in appearance where as the latter showed calcium deficiency symptoms (63, 83, 148, 166).

Lime applications to five North Carolina soils greatly increased the growth and divalent cation content of snap beans (164). In peppers, decreasing the calcium supply increased the total nitrogen and potash content, had no effect on phosphorus and magnesium but decreased the total carbohydrate and reducing and non-reducing sugars (77).

Ozaki and Ozaki (128) did not find any significant differences in calcium, magnesium, phosphorus and potash content of pepper plants by side-dressed applications of hydrated lime at the rate of 300 and 600 pounds per acre or calcium sprays containing four pounds of calcium chloride per 100 gallons of water.

Calcium ions exert influence by their antagonistic effect on the absorption by the plant of some other ions (51, 84, 102, 167). The effect of active calcium on the supply of available phosphorus is of special significance. It has been found that application of lime to acid soils increases the amount of readily soluble phosphorus (110).

According to Alexander and Stark (4) and Lucas and De Freistas (91), greatest growth occured when either nitrogen or calcium was low, increasing concentration of either failed to increase the plant growth. Street (154) cites numerous authors whose work suggest that deficiency of calcium interrupts nitrogen metabolism by its effect on nitrate absorption rather than on its reduction. Nightingale (115) reported that in the presence of calcium some species were unable to absorb nitrates.

Greenhouse experiments by Geraldson (59, 60) using nutrient culture indicated that blossom-end rot of peppers caused by a deficiency of calcium or by excess soluble salts in substrate could be controlled by a 0.04M calcium chloride solution spray applied approximately every five days. He also used calcium sprays in the field with satisfactory results. In sand culture experiments conducted by Taylor and Smith (160) increase in the incidence of blossom-end rot was obtained at low calcium and high nitrogen levels. Plant analysis revealed that plants susceptible to blossom-end rot were lower in calcium and higher in total nitrogen. These results were later confirmed by Miller (100, 101).

Fiskell and Yuan (56) found that blossom-end rot occured when tomatoes were grown on acid soils even in the presence of a comparatively

large amount of calcium in the fertilizer. Similar results were reported by Geraldson (60). It was found by Miller (100) that the addition of 2,750 pounds per acre of gypsum to a soil initially low in calcium resulted in a significant reduction in the incidence of blossom-end rot of peppers, particularly in the early portion of the harvest season, a similar response reported previously by Higgins (73).

In experiments by Ozaki and Ozaki (131), increasing the hydrated lime applications to 4,000 pounds per acre significantly reduced the number of fruits affected with blossom-end rot. Early yield of U.S. Fancy peppers and early combined yield of all fruits including culls were highest on plots receiving one ton of hydrated lime (126). According to Parker, Bailey and Morris (135), on a fertile soil with pH of 5.4 pepper yields were not increased by fertilizer nutrients or lime. In one year, on acid soil of low fertility pepper yields were increased by nitrogen, phosphorus and potash applications, especially when lime was also applied. With pimentoes, Hamilton and Ogle (62) obtained progressively greater number and yield of fruit from calcium treatments of 0, 1, and 4 milliequivalents.

EXPERIMENTAL PROCEDURES

Preliminary Greenhouse Experiments

Two factorial experiments were conducted in 10-inch or 8-inch diameter pots in the Spring of 1960. The first experiment included two varieties of peppers (California Wonder and Yolo Wonder), two levels of nitrogen (100 and 150 pounds per acre), and two treatments of deflowering (normal plant growth or no removal and flowers removed after anthesis but before gametic union). Blossom removal treatment was made by removing five flowers from each plant on alternate days for three weeks. The second experiment included two varieties (Early Calwonder and Florida Giant), two levels of nitrogen (150 and 200 pounds per acre), and two levels of potash (200 and 300 pounds per acre). Sources of nitrogen and potash were nitrate of soda and sulfate of potash respectively.

Applications of fertilizers were split at two-week intervals to meet the total requirement. Weekly observations on plant height and stem diameter were taken. Vernier calipers were used for measuring the stem diameter near the previously marked first node above the ground level.

The treatments of a third experiment conducted in the Fall of 1960 were arranged in a randomized block design with two replications.

Eight levels of nitrogen (0, 50, 100, 150, 200, 250, 300, and 350 pounds per acre) were tested using nitrate of soda. Five equal applications of nitrogen were applied at two-week intervals to meet the total requirement for each treatment.

A fourth experiment in 1960 consisted of five different treatments of deflowering or defruiting arranged in a randomized block design using Florida Giant variety. The treatments were:

(1) normal plant growth, or no blossom and fruit removal;

(2) removal of young flower buds;

(3) removal of mature flower buds before anthesis;

(4) removal of flowers after anthesis, but before gametic union; and

(5) removal of young developing fruits.

The deflowering and defruiting treatments were made during a two-week period in the early part of December, and during this time five flowers or fruits were removed from each plant except the controls. A mixture of 4-8-8 fertilizer was used uniformly at rate of 2,000 pounds per acre for all the treatments in order to maintain an adequate nutrient level in the soil. Weekly records were taken on the height of plant and stem diameter until January 1, 1961 when the experiment was terminated without obtaining the yield data, because of a severe virus infection. However, a count was made of the number of fruits present on each of the plants at the termination of the experiment.

The fifth greenhouse experiment in 1960 consisted of three levels of nitrogen (50, 100, and 150 pounds per acre), two levels of phosphorus (100 and 200 pounds per acre), and two levels of potash (100

and 200 pounds per acre). Nitrate of soda, super phosphate, and sulfate of potash were used as sources for nitrogen, phosphorus and potash respectively. These materials were applied in four equal applications at two-week intervals. Fertilizers were applied in the pots at the soil surface and worked in by hand. Weekly measurements were taken on height of plants and stem diameter. Leaf samples for mineral analysis were taken at the termination of the experiment but no yield data were obtained.

Field Experiments

Excision of Flowers and Fruits, and Nutrition

In 1960, a field experiment was conducted to test three varieties of peppers, three levels of nitrogen and three conditions of deflowering or defruiting. These treatments were arranged factorially on Arredondo fine sand located at the Horticultural unit of the University of Florida, Gainesville, Florida. The pepper varieties planted in this experiment were Florida Giant, Yolo Wonder, and California Wonder. The three levels of nitrogen tested were at the rates of 100, 150, and 200 pounds per acre obtained by supplementing the basic fertilizer with three side-dressings of nitrate of soda. The three deflowering or defruiting treatments were normal plant growth-no blossom or fruit removal; removal of blossoms after anthesis but before fertilization or gametic union; and the removal of young developing fruits. Deflowering and defruiting treatments were made once each week for four weeks.

The individual treatments in the experiment were applied to a single row plot 25 feet in length planted with 12 pepper plants. Rows

in the field were spaced 34 inches apart. After adequate land preparation all plots of the experiment were fertilized with an application of a 4-8-8 fertilizer at the rate of 1,000 pounds per acre, the fertilizer being placed in bands to each side of the row by machine. The plots selected for differential rates of nitrogen received the first of three side-dressings of nitrate of soda by applying the material in a 3-inch band on both sides of the row and covering with soil. Subsequent side-dressings of nitrogen were made in a similar manner.

Six harvests were made during the period May 25 to June 28. The peppers were graded as U.S. Fancy, U.S. No. 1, and culls according to the United States Standards (169). The number and weight of U.S. Fancy and U.S. No. 1, and weight of culls were recorded separately. The plant height measurements and plant counts were made on July 12, 1960 when the experiment was terminated.

In the 1961 field experiment the three variable factors studied were three levels of calcium sulfate consisting of 0, 500, and 1,000 pounds per acre, three conditions of deflowering and defruiting, and three levels of nitrogen. The number and length of rows, size of individual plots, and design of experiment were the same as used in the Spring of 1960. Only one variety, Yolo Wonder, was used, since it was found to be the highest yielder in the 1960 experiment. Three conditions of deflowering and defruiting were: normal plant growth or no removal; removal of young flower buds and removal of young developing fruits. The three levels of nitrogen tested were 50, 100, and 150

pounds per acre. Nitrogen applications were made as in Spring 1960 except that the total amount of 4-8-8 fertilizer was reduced to 1,000 pounds per acre and the treatment levels of nitrogen varied from 50 to 150 pounds per acre. The hand application of calcium sulfate, as gypsum, was made in a furrow in the middle of the rows one week before transplanting. This was covered by machine and the beds for planting prepared. The deflowering or defruiting treatments were made by the removal of five flower buds or fruits from each plant during a 23-day period employing a tag system for accounting. Tags were removed after the deflowering or defruiting was completed for each plant. Flowers were gently removed using a pair of forceps and the fruits were clipped from the plant with a pair of scissors.

Five harvests were made during the period June 23 to July 31, 1961. The pepper fruits were graded in the same manner as in 1960. Additional field records included the recording of the number of fruits affected with blossom-end rot and sunburn and the height measurements of eight plants randomly selected from each plot. The latter measurements were taken on August 1, 1961, when the experiment was terminated.

The amount of rainfall recorded in an area adjoining the experiments is presented in Table 2 for the period of time during which the tests were conducted.

Chemical Deflowering and Defruiting

Four factorial experiments in a randomized block design with three replications were conducted on Arredondo fine sand at the Horticultural

TABLE 2

BIMONTHLY RECORDS OF RAINFALL AT THE HORTICULTURAL UNIT OF THE UNIVERSITY OF FLORIDA, GAINESVILLE, FLORIDA FROM MARCH 1 THROUGH JULY 31 OF 1960 AND 1961

Month and date	Rainfall (inches) 1960	1961
March 1-15	1.65	0.01
March 16-31	6.66	4.75
April 1-15	0.35	2.17
April 16-30	3.05	2.75
May 1-15	1.53	1.50
May 16-31	0.45	0.40
June 1-15	1.78	2.53
June 16-30	8.37	2.71
July 1-15	2.10	4.90
July 16-31	7.75	3.81
Total	33.69	25.53

Unit of the University of Florida, Gainesville, Florida. Each experiment included the testing of a chemical with four concentrations at three stages of blooming (pre-bloom, bloom and post-bloom). The four chemicals used were:

(1) naphthaleneacetic acid (auxin)--0, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} Molar concentrations;

(2) gibberellic acid (auxin-enhancing agent)--0, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} Molar concentrations;

(3) trans-cinnamic acid (anti-auxin)--0, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} Molar concentrations; and

(4) sodium 2,3-dichloroisobutyrate (gametocide)--0, 0.35, 0.25, 0.15 and 0.05 per cent concentrations.

Each plot of the experiment measured 6 feet by 34 inches in size. Planting of the pepper seedlings was made on April 11, 1961 and the plants were spaced two feet apart. Each plot included three plants. All the experimental fields were fertilized uniformly with a mixture of 4-8-8 fertilizer at the rate of 1,200 pounds per acre prior to transplanting. Each of the chemicals was weighed, dissolved and made to volune with water. Solutions were sprayed on the plant using a hand atomizer. Sufficient solution was used to completely wet the foliage of the plant--about 200 ml. for nine plants.

Chemical Analyses

Soil Samples

Soil samples were taken from each plot in 1960 on March 21 and July 11 and in 1961 on April 3, June 29 and August 1. Samples were

dried on greenhouse benches, seived and mixed thoroughly before the analyses were made. Samples were analyzed for pH, available P_2O_5, K_2O, CaO and MgO in pounds per acre by the Soil Testing Laboratory of the University of Florida, Gainesville, Florida. The analysis of the samples for total nitrogen was made by the improved microkjeldahl method (10).

Tissue Samples

Mature leaf samples were taken from the lower portion of the stems of the plants from each plot at the termination of the experiment in 1960 and twice (July 6 and August 1) during 1961. Leaves selected for analysis were considered as having finished their growth but were physiologically active. The time of sampling in each case was between 7:00 and 10:00 a.m. Some of the material was used for the determination of reducing and total sugars and the remaining saved for mineral analysis.

The material for sugar analysis was rapidly chopped into small pieces and thoroughly mixed. Twenty-five grams of fresh material were weighed and placed in one-pint Mason jars which contained 0.5 grams of calcium carbonate. Ethanol, 140 ml. of 95 per cent, was added and samples boiled on a hot plate for five minutes. The jars were sealed and stored in a dark place until the analysis could be made. Determinations on reducing and total sugars were made by the method as described by Moyer and Holgate, using a spectronic "20" colorimeter (104).

Samples for mineral analysis were dried at 70°C for 48 hours in a circulatory oven, ground in a Wiley mill and stored in four-ounce bottles. Total nitrogen in the leaf samples was determined by macrokjeldahl method in the Spring of 1960 and by microkjeldahl method in the Spring of 1961 depending on the availability of the equipment. For the analysis of other elements, 1-gram samples of oven-dried tissue were ashed in a muffle furnace at 450°C, dissolved in 20 ml. of 40 per cent hydrochloric acid (HCl), evaporated to dryness, dissolved in 3 ml. concentrated nitric acid, reheated in the muffle furnace at 450°C for 15 minutes, dissolved in 1 ml. of concentrated HCl, evaporated to dryness and diluted to volume with 0.1 normal HCl. All samples were analyzed for potassium, calcium, magnesium, and sodium on Beckman flame spectrophotometer models B and DU as outlined in a procedure described by Breland (27). Samples for calcium and magnesium were allowed to pass through ion-exchange columns before the analysis as reported by Horn (76). Phosphorus determinations were made by colorimetric method using spectronic "20" colorimeter (10).

Statistical Methods

Statistical analyses of the data were made by the method of analysis of variance as described by Cochran and Cox (38). Treatment mean comparisons were made by Duncan's Multiple Range Test (48) and L.S.D. test. Arcsin transformations of percentage data and test of homogeneity of variances were made as described by Snedecor (151).

EXPERIMENTAL RESULTS

Growth and Fruiting Responses

Preliminary Greenhouse Work

Experiment No. 1.--In 1960 the first experiment was organized to study the effect of variety, nitrogen and deflowering on the growth of pepper plants. The average increase in the plant height and stem diameter resulting from the treatments during a 4-week period, from May 8 to June 5, 1960 are presented in Table 3. Plants from which the blossoms were removed after anthesis were found to have significantly greater average increase in the height as compared with plants from which no blossoms were removed. There was a highly significant interaction between varieties and the rate of nitrogen application. The rate of nitrogen at 100 pounds per acre in the soil of the pots planted to the variety Yolo Wonder resulted in a significant decrease in the average height as compared with California Wonder. With the variety Yolo Wonder a significant increase in the height of pepper plants was found as the levels of nitrogen were raised from 100 to 150 pounds per acre. The plants of the variety California Wonder, when deflowered, produced plants with greater average increase in the height than untreated plants. There was no interaction between nitrogen and deflowering treatments on the plant height. No significant effects were found

TABLE 3

EFFECT OF VARIETY, NITROGEN AND DEFLOWERING ON THE AVERAGE INCREASE IN THE HEIGHT AND STEM DIAMETER OF PEPPER PLANTS*

Variety	Nitrogen (lbs/A)		Deflowering		Average
	100	150	Untreated	Deflowered	
			Height (inches)		
California Wonder	2.81	2.07	1.70	2.78	2.24
Yolo Wonder	1.58	2.43	1.73	2.27	2.00
Average	2.20	2.25	1.72	2.52	2.12
			Stem diameter (inches)		
California Wonder	0.056	0.048	0.048	0.056	0.052
Yolo Wonder	0.064	0.072	0.060	0.072	0.068
Average	0.060	0.060	0.056	0.064	0.060

L.S.D. (Least Significant Difference)	Height 5%	1%
Between deflowering averages	0.58	0.83
Between interactions (V x N)	0.84	1.19

*During a 4-week period (May 8 to June 5)

due to nitrogen, variety and deflowering treatments on the average increase in the diameter of the stem of pepper plants during a 4-week period.

Experiment No. 2.--In a second greenhouse experiment during the year 1960 an attempt was made to further study the effects of pepper varieties and nitrogen rates at two potash levels on the height and stem diameter of plants. The results of this test are presented in Table 4. The data indicate that the variety Early Calwonder had a significantly greater increase in the height of plants as compared with the variety Florida Giant. Increasing the potash levels from 200 to 300 pounds per acre resulted in significantly greater increase in the average plant height. Raising the level of nitrogen from 150 to 200 pounds per acre did not result in a significant increase in the average height of the pepper plants. There was no interaction between any of the treatments. The effects of the treatments on the average increase in the stem diameter were not significant.

Experiment No. 3.--In 1960, the third greenhouse experiment was conducted to test the effects of eight different levels of nitrogen on the growth of pepper plants. The rates of nitrogen tested ranged from 0 to 350 pounds per acre. No records were taken on the height of pepper plants but it was observed that increasing the nitrogen level from 0 to 100 pounds per acre in the soil of the pots had increasing effect on the growth and the rates of nitrogen higher than 100 pounds had an injurious effect as indicated by stunted growth and burning of the leaves.

TABLE 4

EFFECT OF VARIETY, NITROGEN AND POTASH LEVELS ON THE AVERAGE INCREASE IN THE HEIGHT AND STEM DIAMETER OF PEPPER PLANTS*

Variety	Nitrogen (lbs/A) 150	Nitrogen (lbs/A) 200	Potash (lbs/A) 200	Potash (lbs/A) 300	Average
			Height (inches)		
Early Calwonder	1.61	1.60	1.24	2.09	1.51
Florida Giant	0.70	1.01	0.60	1.11	0.86
Average	1.16	1.31	0.86	1.60	1.18
			Stem diameter (inches)		
Early Calwonder	0.021	0.022	0.019	0.024	0.022
Florida Giant	0.027	0.027	0.028	0.028	0.028
Average	0.024	0.025	0.024	0.026	0.025

L.S.D.	Height 5%	1%
Between variety averages	0.64	0.91
Between potash averages	0.64	0.91

*During a 3-week period (May 8 to May 29)

Experiment No. 4.--A fourth experiment in the greenhouse was designed to further test the influence of different treatments of blossom and fruit removal on the average growth of pepper plants and subsequent fruit set. The results of this test are presented in Table 5. The removal of flowers or fruits resulted in a significant average increase in the height of the pepper plants when measured during a six-week period, from November 21, 1960 to January 1, 1961. It is apparent from the data that the greatest increase in the average height of pepper plants was obtained when the young flower buds were removed or on the removal of young developing fruits. The average height increase in the pepper plants, from which the young flower buds and young developing fruits were removed, was significantly greater as compared with the plants where no removal was done. The average increases in height due to the removal of mature flower buds and flowers after anthesis were significantly less as compared with the removal of young flower buds.

This experiment was terminated on February 2, 1961 and the number of fruits in each experimental unit was recorded. The treatment which consisted of removing the young flower buds, as shown in Table 5, had a highly significant effect on increasing the number of fruits in comparison to the removal of mature flower buds or the control treatment. A relationship was found between the average number of fruits to the average increase in the height of the plants. The calculated coefficient of correlation was found to be $r = 0.92$.

TABLE 5

EFFECT OF BLOSSOM AND FRUIT REMOVAL ON THE AVERAGE INCREASE IN THE PLANT HEIGHT* AND AVERAGE NUMBER OF PEPPER FRUITS**

Treatment	Date of Measurement: November 21 Ht. (in.)	Date of Measurement: January 1 Ht. (in.)	Average increase	Average No. of Fruits
A. No removal or control	5.82	7.67	1.85	3
B. Removal of young flower buds	5.60	11.75	6.15	18
C. Removal of mature flower buds	5.41	8.72	3.31	6
D. Removal of flowers after anthesis	5.68	9.50	3.82	8
E. Removal of young developing fruits	6.04	10.28	4.24	12

Average height increase

A C D E B

Average number of fruits

A C D E B

Any two observations underscored by the same straight line are not significantly different.

*During a period of 6 weeks (November 21, 1960 to January 1, 1961).

**Number of fruits per experimental unit on February 2, 1961.

Experiment No. 5.--The fifth greenhouse experiment conducted in the Fall of 1960 was directed at studying the effects of various levels of nitrogen, phosphorus and potash on the growth of pepper plants. The results of this test are shown in Table 6. It was found that there was an interaction among nitrogen, phosphorus, and potash levels on the average height of pepper plants. When 50 pounds of nitrogen and 150 pounds of phosphorus per acre were applied in the pots, there was significant increase in the average height of the pepper plants by increasing the potash levels from 100 to 200 pounds per acre.

Field Phase

Growth Responses

Field Experiment, 1960.--The results are presented in Table 7 on the average height of pepper plants for 1960 as affected by pepper varieties, different treatments of deflowering or defruiting and various levels of nitrogen. It is indicated from the data that the plants of the variety Yolo Wonder were taller than the plants of the varieties Florida Giant and California Wonder. However, there was no difference between the average plant height of the varieties Florida Giant and California Wonder. An interaction of nitrogen levels with deflowering or defruiting treatment was found. When the plants were deflowered, the plant height was increased in comparison with no removal treatment by applying nitrogen at the rate of 100 pounds per acre. On the other hand, when the plants were defruited, the height

TABLE 6

EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ON THE AVERAGE HEIGHT AND STEM DIAMETER OF PEPPER PLANTS*

Potash (lbs/A)	Nitrogen (lbs/A) 50		100		150		Average
	Phosphorus (lbs/A) 100	200	100	200	100	200	
			Height (inches)				
100	11.13	11.20	11.54	12.37	11.76	12.25	11.71
200	13.27	12.18	11.63	12.75	12.85	10.25	12.15
Average	12.19	11.69	11.58	12.56	12.30	11.25	11.93
			Stem diameter (inches)				
100	0.166	0.158	0.155	0.188	0.190	0.183	0.173
200	0.176	0.168	0.166	0.193	0.162	0.176	0.173
Average	0.171	0.163	0.160	0.190	0.176	0.179	0.173

L.S.D.	Height 5%	1%
Between interactions (NxPxK)	2.06	2.80

*Based on the final average height measured on December 11, 1960.

TABLE 7

EFFECT OF VARIETY, DEFLOWERING, AND NITROGEN ON THE AVERAGE HEIGHT (INCHES) OF PEPPER PLANTS--1960

Nitrogen (lbs/A)	Variety			Deflowering or defruiting			
	Florida Giant	Yolo Wonder	California Wonder	Untreated	Deflowered	Defruited	Average
100	15.32	17.66	16.26	15.97	16.98	16.29	16.41
150	15.92	17.52	15.80	15.94	16.53	16.78	16.42
200	16.17	17.48	16.51	16.12	16.78	17.48	16.72
Average	15.81	17.56	16.19	16.01	16.69	16.85	16.52

L.S.D.	5%	1%
Between variety averages	0.52	0.68
Between deflowering or defruiting averages	0.52	0.68
Between interactions (D x N)	0.88	1.25

was significantly increased as compared with untreated plants by the nitrogen application at the rate of 200 pounds per acre. There was no interaction between variety and nitrogen levels, or variety and deflowering or defruiting treatments.

Field Experiment, 1961.--The results on the height of the pepper plants as influenced by different treatments of deflowering and defruiting, levels of nitrogen and calcium are presented in Table 8. A positive linear response in the average plant height was obtained by increasing the rates of nitrogen application from 50 to 150 pounds per acre. The deflowered plants were significantly taller than untreated plants (Fig. 1) but were not different from defruited plants. When the plants were defruited, a significant decrease in the average height resulted from increasing the level of calcium sulfate from 0 to 500 pounds per acre. When the plants were not deflowered or defruited, a decrease in the height of pepper plants was obtained from 0 to 500 pounds per acre of calcium sulfate and an increase from 500 to 1,000 pounds per acre. There were no other interactions between the several treatments.

It was observed in the field in 1961 that the plants which received low nitrogen (50 pounds per acre) and were not deflowered or defruited, were stunted and showed chlorosis of the leaves. Plants which received high nitrogen and were deflowered or defruited were dark green and vigorous. The deflowered or defruited plants seemed to have a greater leaf area as observed in the field; however, no measurements on leaf area were taken.

TABLE 8

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE HEIGHT (INCHES) OF PEPPER PLANTS--1961

Deflowering or Defruiting	Nitrogen (lbs/A)			Calcium sulfate (lbs/A)			Average
	50	100	150	0	500	1,000	
Untreated	14.90	15.30	16.50	16.50	14.80	15.30	15.50
Deflowered	16.10	16.80	17.00	15.90	16.80	17.20	16.60
Defruited	15.40	16.00	16.30	16.40	15.10	15.90	16.00
Average	15.40	16.00	16.60	16.40	15.60	16.10	16.00

L.S.D.	5%	1%
Between deflowering or defruiting averages	0.72	0.95
Between calcium sulfate averages	0.72	0.95
Between nitrogen averages	0.72	0.95
Between interaction (D x C)	1.19	1.58

Fig. 1. Effect of deflowering on the growth and fruiting of Yolo Wonder pepper plants (row on the left--undeflowered; row on the right--deflowered).

Fruit Set

Field Experiment, 1960.--The results of the field experiment begun in the Spring 1960 on the yield of peppers are reported by individual grades and time of harvest. U.S. Fancy Peppers: The average number of fruits and bushels per acre of U.S. Fancy peppers picked from the variety Yolo Wonder was greater than that harvested from the variety Florida Giant but the yield of this grade was not greater than the variety Florida Giant as indicated by the data in Table 9. The yield from the variety California Wonder was greater than that harvested from the Florida Giant in respects to both the number and bushels per acre of U.S. Fancy fruits. Although, there were no differences obtained in the yield of U.S. Fancy peppers from the deflowering or defruiting treatments, an interaction was found between these treatments with the levels of nitrogen tested. Deflowered and untreated plants growing on plots which had the level of nitrogen fertilizer raised from 100 to 150 pounds per acre showed a decrease in the number and bushels per acre of fruit. However, no differences in the yield were found of the fruit from the defruited plants with any increase in the level of nitrogen tested.

U.S. No. 1 Peppers: The yield data for U.S. No. 1 peppers (Table 10) showed no differences resulting from the treatments of deflowering or defruiting and levels of nitrogen. However, differences in the yield were found among varieties. The variety Yolo Wonder produced the highest number of fruits and bushels per acre when compared with the

TABLE 9

EFFECT OF VARIETY, DEFLOWERING OR DEFRUITING AND NITROGEN ON THE AVERAGE YIELD OF U.S. FANCY PEPPER FRUITS--1960

Nitrogen (lbs/A)	Deflowering or defruiting			Variety			
	Untreated	Deflowered	Defruited	Florida Giant	Yolo Wonder	California Wonder	Average
	Number of Fruits/Acre						
100	18,054	19,278	13,872	11,424	20,757	19,023	17,085
150	12,597	13,362	14,433	9,843	15,351	15,198	13,464
200	13,515	12,954	12,903	8,976	16,014	14,382	13,107
Average	14,739	15,198	13,719	10,098	17,391	16,218	14,535
			Bushels/acre				
100	217.03	252.39	179.88	141.18	266.48	241.63	216.52
150	157.84	171.16	180.90	118.38	192.43	198.84	169.88
200	167.32	164.25	171.93	101.41	208.83	185.00	167.83
Average	180.64	195.76	177.57	122.99	222.67	208.58	184.74

L.S.D.	Numbers of fruits/Acre 5%	1%	Bushels/Acre 5%	1%
Between variety averages	1,799	2,387	23.36	31.07
Between nitrogen averages	1,799	2,387	23.36	31.07
Between interactions (D x N)	3,127	4,149	40.83	54.18

TABLE 10

EFFECT OF VARIETY, DEFLOWERING OR DEFRUITING AND NITROGEN ON THE AVERAGE YIELD OF U.S. NO. 1 PEPPER FRUITS--1960

Nitrogen (lbs/A)	Deflowering or defruiting			Variety			Average
	Untreated	Deflowered	Defruited	Florida Giant	Yolo Wonder	California Wonder	
			Number of fruits/acre				
100	14,229	15,861	14,484	14,076	16,269	14,229	14,841
150	13,464	15,657	13,770	13,821	17,748	11,322	14,280
200	12,954	12,444	13,209	10,812	16,116	11,679	12,852
Average	13,566	14,637	13,821	13,056	16,728	12,393	13,974
			Bushels/acre				
100	131.45	138.37	129.91	123.50	145.54	130.68	133.24
150	191.92	141.44	125.81	120.94	160.15	106.34	129.14
200	113.77	116.84	119.66	98.14	145.28	106.59	116.84
Average	121.71	132.22	125.04	114.28	150.41	114.54	126.44

	Numbers of fruits		Bushels/Acre	
L.S.D.	5%	1%	5%	1%
Between variety averages	2,356	3,127	16.69	22.34

varieties Florida Giant and California Wonder. No differences in the number of fruits and bushels per acre of peppers were obtained between the varieties Florida Giant and California Wonder. No interactions were found among the various treatments.

Total Marketable Peppers: Considerable varietal differences were found in the total marketable yield (U.S. Fancy and U.S. No. 1) as shown by the data in Table 11. The variety Yolo Wonder produced a greater number and bushels per acre of fruits than either the variety Florida Giant or California Wonder. The variety California Wonder produced a greater number of fruits and more bushels per acre than the variety Florida Giant (Fig. 2). An interaction occured between treatments involving blossom or fruit removal and nitrogen levels. When the flower buds were removed after anthesis but before gametic union, a decrease in the number and bushels of peppers was obtained by raising the level of nitrogen from 100 to 200 pounds per acre. When no flowers or fruits were removed, there was a significant decrease in the number and bushels of fruits when nitrogen application in the soil was increased from 100 to 150 pounds per acre. No other interactions were found among several treatments on the total marketable yield of peppers.

Cull Peppers: The data from the harvest of the cull yield of peppers are included in Table 12. The only differences in the yield with the cull grade of peppers were found between varieties. The average yields for the varieties Florida Giant, Yolo Wonder and California

TABLE 11

EFFECT OF VARIETY, DEFLOWERING OR DEFRUITTING AND NITROGEN ON THE AVERAGE TOTAL MARKETABLE YIELD OF PEPPER FRUITS--1960

Nitrogen (lbs/A)	Deflowering or defruiting			Variety			
	Untreated	Deflowered	Defruited	Florida Giant	Yolo Wonder	California Wonder	Average
			Number of fruits/acre				
100	32,283	35,139	28,356	25,500	37,026	33,252	31,926
150	26,061	29,019	28,203	23,664	33,099	26,520	27,744
200	26,469	25,398	26,112	19,788	32,130	26,061	25,959
Average	28,254	29,835	27,540	23,001	34,068	28,611	28,560
			Bushels/acre				
100	348.48	390.76	309.79	264.43	412.02	372.31	349.76
150	277.80	312.61	306.71	239.32	352.58	305.18	299.03
200	281.35	281.09	291.34	207.81	354.12	291.60	284.68
Average	302.61	328.24	302.61	237.27	373.08	323.11	311.16

L.S.D.	Number of fruits		Bushels/Acre	
	5%	1%	5%	1%
Between variety averages	3,188	4,231	25.42	33.89
Between nitrogen averages	3,188	4,231	25.42	33.89
Between interactions (D x N)	3,990	5,293	31.58	41.85

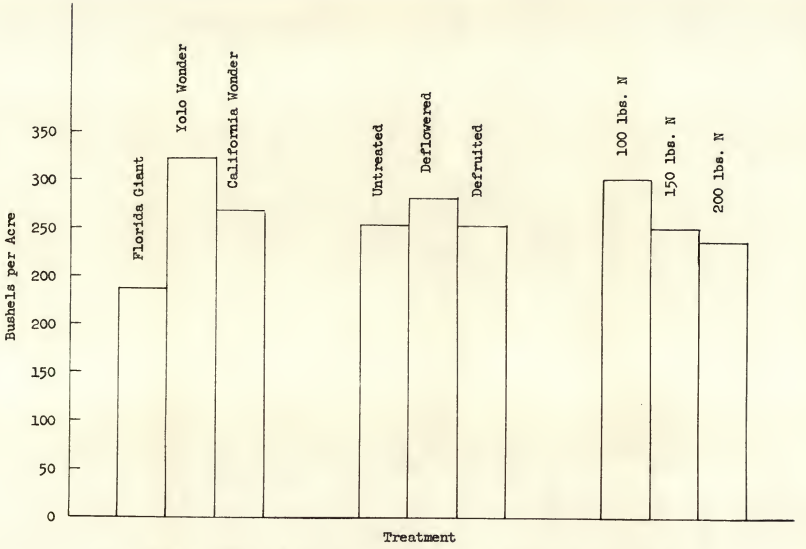

Fig. 2. Effect of variety, deflowering or defruiting and nitrogen on the average total marketable yield of peppers--1960.

TABLE 12

EFFECT OF VARIETY, DEFLOWERING OR DEFRUITING AND NITROGEN ON THE AVERAGE YIELD OF CULL PEPPER FRUITS--1960

Nitrogen (lbs/A)	Deflowering or defruiting			Variety			Average
	Untreated	Deflowered	Defruited	Florida Giant	Yolo Wonder	California Wonder	
				Bushels/acre			
100	157.72	164.78	159.22	185.97	170.56	125.19	160.57
150	179.76	178.05	189.60	191.10	217.42	138.89	182.47
200	156.86	169.70	191.74	207.37	166.71	144.24	172.77
Average	164.78	170.84	180.19	194.81	184.90	136.10	171.93

L.S.D.	5%	1%
Between variety averages	22.83	29.01

Wonder were 194.81, 184.91, and 136.10 bushels per acre respectively. The yield of the variety California Wonder was lower than the other two varieties with no differences being found between the yields of Florida Giant and Yolo Wonder.

Early and Late Yields: The effects of several treatments on the early and late yields of marketable peppers (U.S. Fancy and U.S. No. 1) are presented in Tables 13 and 14. The first three of the six harvests were classified as the early yield with the last three harvests as the late yield. It was found that the highest early yield was harvested from the variety Yolo Wonder, and this yield was different than that harvested from the Florida Giant variety but not different from that harvested from California Wonder. The variety California Wonder, however, produced a greater early yield than the variety Florida Giant. The treatments of deflowering or defruiting and levels of nitrogen had no effect on the early yield of peppers.

The data on the late yield showed that raising the nitrogen level from 100 to 200 pounds per acre resulted in a significant decrease in the bushels of peppers obtained when the plants were untreated and deflowered. However, the yield harvested from defruited plants was decreased as the levels of nitrogen were increased from 100 to 150 pounds per acre. When the nitrogen was applied at 100 pounds per acre, the yield was significantly increased by removing the flower buds as compared with no removal treatment. In general, increasing the level of nitrogen from 100 to 200 pounds per acre reduced the yield of all the three

TABLE 13

EFFECT OF VARIETY, DEFLOWERING OR DEFRUITING AND NITROGEN ON THE AVERAGE EARLY AND LATE YIELD OF MARKETABLE PEPPERS--1960

Nitrogen (lbs/A)	Deflowering or defruiting			Variety			
	Untreated	Deflowered	Defruited	Florida Giant	Yolo Wonder	California Wonder	Average
			Early yield (Bushels/acre)				
100	178.69	155.58	140.38	123.05	175.05	176.55	158.14
150	164.14	179.33	176.76	124.12	200.90	196.02	173.34
200	152.80	159.00	137.39	104.86	170.99	173.34	149.59
Average	165.01	164.57	151.51	117.27	182.11	160.50	160.29
			Late yield (Bushels/acre)				
100	170.56	236.04	170.13	142.10	237.97	196.97	192.17
150	114.28	133.96	130.54	115.77	153.22	109.78	126.26
200	129.04	122.62	154.72	103.36	184.04	118.98	135.46
Average	138.03	164.14	159.00	120.48	191.74	141.88	151.30

L.S.D.	Early yield 5%	Early yield 1%	Late yield 5%	Late yield 1%
Between variety averages	24.90	33.12	25.28	31.96
Between deflowering or defruiting averages	-	-	25.28	31.96
Between nitrogen averages			25.28	31.96
Between interactions (D x N)	-	-	34.90	43.12
Between interactions (V x N)	-	-	34.90	43.12

TABLE 14

EFFECT OF VARIETY AND DEFLOWERING OR DEFRUITING INTERACTION ON THE LATE YIELD OF MARKETABLE PEPPERS--1960

Deflowering or Defruiting	Variety			Average
	Florida Giant	Yolo Wonder	California Wonder	
		Bushels/acre		
Untreated	128.84	152.37	138.67	138.03
Deflowered	126.26	219.78	146.59	164.14
Defruited	112.14	203.09	140.17	159.00
Average	120.48	191.74	141.88	151.30

L.S.D.	5%	1%
Between variety averages	25.28	31.96
Between deflowering or defruiting averages	25.28	31.96
Between interactions (V x D)	34.90	43.12

varieties. From the data in Table 14, it is indicated that Yolo Wonder was the only variety which responded to the deflowering or defruiting treatment. Deflowered and defruited plants of the variety Yolo Wonder produced a greater late yield in comparison with the plants from which no flowers or fruits were removed.

Weight Per Fruit of U.S. Fancy and U.S. No. 1 Peppers: The average weight per fruit of U.S. Fancy peppers was affected by variety and the deflowering or defruiting treatments (Table 15). The variety Yolo Wonder produced U.S. Fancy fruits which were heavier in average weight than the fruits of the variety Florida Giant. There was no significant difference in the average weight per fruit between the varieties Yolo Wonder and California Wonder. There was an increase in the average weight of the fruits when the pepper plants were deflowered or defruited in comparison with the average weight of the fruits where no flowers or fruits were removed. The U.S. Fancy fruits harvested from the deflowered plants did not differ in average weight as compared with the fruits of the defruited plants.

There was an interaction of the deflowering or defruiting treatments with the levels of nitrogen on the average weight per fruit of U.S. No. 1 peppers as shown by the data in Table 15. The raising of the nitrogen level from 100 to 200 pounds per acre resulted in a significant increase in the average weight of the fruit when the flowers were removed after anthesis.

Field Experiment, 1961.--The results for the field tests begun in the Spring of 1961 on the yield and quality of pepper fruits are

TABLE 15

EFFECT OF VARIETY, DEFLOWERING OR DEFRUITING AND NITROGEN ON THE AVERAGE WEIGHT PER PEPPER FRUITS--1960

Nitrogen (lbs/A)	Deflowering or defruiting			Variety			
	Untreated	Deflowered	Defruited	Florida Giant	Yolo Wonder	California Wonder	Average
			U.S. Fancy (gm/fruit)				
100	131.66	140.74	140.74	136.20	140.74	136.20	137.71
150	131.66	136.20	136.20	131.66	136.20	136.20	134.69
200	131.66	136.20	140.74	131.66	140.74	136.20	136.36
Average	131.66	137.71	139.23	133.19	139.23	136.20	136.25
			U.S. No. 1 (gm/fruit)				
100	99.88	95.34	99.88	95.34	99.88	99.88	98.36
150	99.88	99.88	99.88	99.88	99.88	104.42	100.63
200	95.34	104.42	99.88	99.88	99.88	99.88	99.88
Average	98.36	99.88	99.88	98.36	99.88	101.39	99.62

L.S.D.	U.S. Fancy 5%	U.S. Fancy 1%	U.S. No. 1 5%	U.S. No. 1 1%
Between variety averages	4.49	8.71	-	-
Between deflowering or defruiting averages	4.49	8.71	-	-
Between interactions (D x N)	-	-	9.03	11.98

presented as follows: U.S. Fancy Peppers: The data on the average number of fruits and bushels per acre of U.S. Fancy fruits are shown in Table 16. An increase in the level of nitrogen from 50 to 150 pounds per acre resulted in a linear increase in number and bushels per acre of U.S. Fancy pepper fruits. Though the several levels of calcium alone had no effect on the number and bushels of peppers, an interaction was found between calcium levels and the treatments of deflowering or defruiting on the number of U.S. Fancy fruits per acre. When no calcium was applied there was an increase in the subsequent number of fruits by defruiting the plants. On the other hand, the number of fruits were increased by removing the young flower buds in comparison with plants from which no flowers or fruits were removed at 500 pounds level of calcium.

U.S. No. 1 Peppers: The number of U.S. No. 1 peppers were not affected by the deflowering or defruiting treatment as shown in Table 17. The number of fruits and bushels per acre were significantly increased in a linear fashion by raising the nitrogen level from 50 to 150 pounds per acre. There was an interaction between calcium levels and the deflowering or defruiting treatments. This was evidenced by a decrease in the bushels of fruit by increasing the calcium sulfate level from 0 to 1,000 pounds per acre when the plants were defruited and an increase in the bushels per acre when the plants were deflowered.

Total Marketable Peppers: The data for total marketable peppers as presented in Table 18, show that marked differences occured in both number and bushels of fruits due to various levels of nitrogen and

TABLE 16

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN, AND CALCIUM ON THE AVERAGE YIELD OF U.S. FANCY PEPPER FRUITS--1961

Calcium Sulfate (lbs/A)	Nitrogen (lbs/A)			Deflowering or defruiting			Average
	50	100	150	Untreated	Deflowered	Defruited	
				Number of fruits/acre			
0	7,038	9,180	9,996	6,426	8,058	11,730	8,727
500	4,692	8,772	13,923	6,783	11,220	9,384	9,129
1000	6,936	8,160	11,934	8,058	11,016	7,956	8,976
Average	6,222	8,721	11,934	7,089	10,098	9,690	8,925
				Bushels/acre			
0	104.86	134.61	153.65	95.87	126.90	170.34	130.97
500	69.34	126.26	208.65	97.16	177.83	129.26	134.61
1000	112.56	126.47	163.28	112.56	161.36	128.40	133.96
Average	95.44	129.04	175.27	101.86	155.36	142.52	133.32

L.S.D.	Number of fruits 5%	Number of fruits 1%	Bushels/Acre 5%	Bushels/Acre 1%
Between deflowering or defruiting averages	2,300	3,052	35.25	46.77
Between nitrogen averages	2,300	3,052	35.25	46.77
Between interactions (D x C)	3,991	5,297	-	-

TABLE 17

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE YIELD OF U.S. NO. 1 PEPPER FRUITS--1961

Calcium Sulfate (lbs/A)	Nitrogen (lbs/A)			Deflowering or defruiting		Average
	50	100	150	Untreated	Deflowered Defruited	
			Number of fruits/acre			
0	10,302	15,147	15,810	12,393	11,424 16,422	13,770
500	9,690	11,730	17,748	11,730	14,790 12,648	13,056
1000	11,373	11,322	14,739	13,362	12,240 11,832	12,495
Average	10,455	12,750	16,116	12,495	18,258 13,617	13,107
			Bushels/acre			
0	99.08	140.81	157.72	108.07	127.12 162.43	132.47
500	88.17	112.99	170.56	100.79	149.80 121.12	123.91
1000	102.08	105.72	148.73	118.13	167.99 70.41	118.77
Average	96.51	119.84	159.00	108.93	133.96 132.25	124.98

L.S.D.	Number of fruits 5%	1%	Bushels/Acre 5%	1%
Between deflowering or defruiting averages	-	-	20.95	27.79
Between nitrogen averages	2,239	2,971	20.95	27.79
Between interactions (D x C)	3,882	5,151	36.79	48.80

TABLE 18

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE TOTAL MARKETABLE YIELD OF PEPPER FRUITS--1961

Calcium Sulfate (lbs/A)	Nitrogen (lbs/A)			Deflowering or defruiting			Average
	50	100	150	Untreated	Deflowered	Defruited	
				Number of fruits/acre			
0	17,340	24,327	25,806	18,819	20,502	28,152	22,491
500	14,382	20,502	31,671	18,513	26,010	22,032	22,185
1000	18,309	19,482	26,673	21,420	23,256	19,788	21,471
Average	16,677	21,420	28,050	19,584	23,256	23,307	22,032
				Bushels/acre			
0	203.94	275.42	307.52	200.09	254.02	332.77	262.36
500	156.86	239.25	364.23	197.95	312.01	250.38	253.38
1000	212.93	232.19	311.58	230.26	286.97	239.47	252.31
Average	191.32	248.88	327.85	212.51	284.41	274.13	255.94

L.S.D.	Number of fruits 5%	Number of fruits 1%	Bushels/Acre 5%	Bushels/Acre 1%
Between deflowering or defruiting averages	3,431	4,554	47.52	63.04
Between nitrogen averages	3,431	4,554	47.52	63.04
Between interactions (D x C)	5,878	7,800	82.78	109.81

interaction of calcium with the treatments of blossom or fruit removal. The raising of the nitrogen levels from 50 to 150 pounds per acre resulted in a linear increase in the number and bushels of total marketable fruits (Fig. 3). An increase in the level of calcium from 0 to 1,000 pounds per acre decreased the yield of peppers when defruiting was done. However, when no calcium was applied, the defruiting of plants resulted in a greater increase in the number and bushels of fruits in comparison with no flower or fruit removal treatment. No differences in the yields resulted at the 1,000 pounds level of the calcium sulfate as a result of flower or fruit removal.

Cull Peppers: The yield of cull fruits as evidenced by the data in Table 19 indicates that an increase in the bushels per acre was obtained by applying calcium from 0 to 1,000 pounds per acre when the flower buds were removed. Other treatments including interactions had no effect on the yield of culls from the pepper plants.

Early and Late Yields: The effects of the several treatments on the early and late yields for the 1961 field tests are presented in Tables 20 and 21. In 1961, the first two of the five harvests were considered as early yield with the last three classed as late yield. It was found that raising the nitrogen level from 50 to 150 pounds per acre resulted in a linear increase of the early yield of peppers. The levels of calcium had an interaction with deflowering or defruiting on the early yield. When no calcium was applied there was an increase in the early yield by removing the fruits as compared with the plants which had no removal of flowers and fruits. However, at the calcium

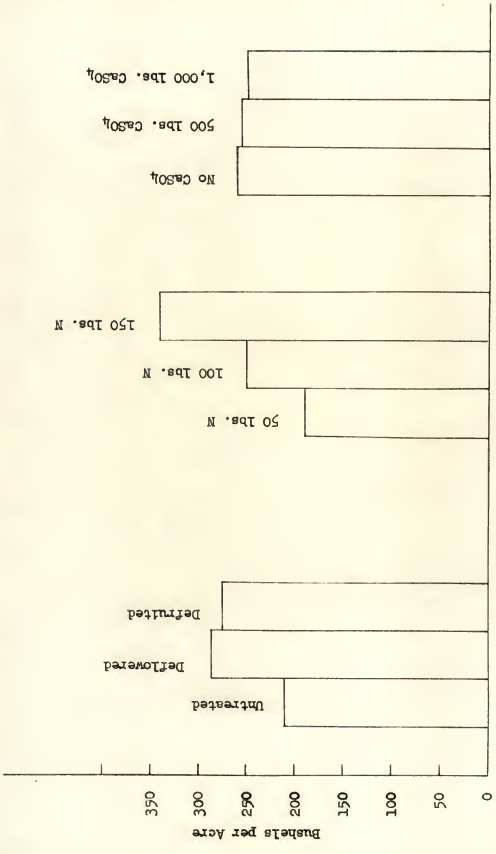

Fig. 3. Effect of deflowering or defruiting, nitrogen and calcium on the average total marketable yield of peppers--1961.

TABLE 19

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE CULL YIELD OF PEPPER FRUITS--1961

Calcium Sulfate (lbs/A)	Nitrogen (lbs/A) 50	100	150	Deflowering or defruiting Untreated	Deflowered	Defruited	Average
				Bushels/acre			
0	166.06	200.52	190.89	189.18	188.11	180.19	185.75
500	173.55	176.55	216.78	172.70	220.63	173.55	188.96
1000	175.91	199.45	201.59	146.38	246.10	184.47	192.39
Average	171.84	192.17	203.09	169.49	218.28	179.33	188.96

L.S.D.	5%	1%
Between deflowering or defruiting averages	31.17	41.35
Between interactions (D x C)	54.16	71.85

TABLE 20

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE EARLY YIELD OF PEPPER FRUITS--1961

Calcium Sulfate (lbs/A)	Nitrogen (lbs/A) 50	100	150	Deflowering or defruited Untreated	Deflowered	Defruited	Average
0	114.49	165.64	153.87	113.85	138.03	182.11	144.80
500	96.51	131.61	164.14	96.09	172.27	123.41	130.89
1000	130.75	142.31	181.69	123.05	192.60	139.10	147.23
Average	114.07	146.52	166.60	113.85	146.59	166.49	142.31

L.S.D.	Early yield 5%	1%
Between deflowering or defruiting average	34.23	45.41
Between nitrogen averages	34.23	45.41
Between interaction (D x C)	51.21	74.56

TABLE 21

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM INTERACTIONS ON THE AVERAGE LATE YIELD OF PEPPER FRUITS--1961

Calcium Sulfate (lbs/A)	Deflowering or defruiting									
	Untreated			Deflowered			Defruited			
	Nitrogen (lbs/A)									
	50	100	150	50	100	150	50	100	150	Average
	Yield (Bushels/acre)									
0	77.56	69.23	111.53	35.26	114.74	197.43	155.12	144.87	151.28	117.49
500	33.33	76.27	195.50	82.05	141.66	194.86	65.38	104.48	208.97	122.62
1000	73.71	104.41	141.02	89.74	72.43	120.51	82.69	90.38	127.56	105.58
Average	61.53	83.97	149.35	69.02	109.61	142.60	101.06	113.24	162.60	113.63
Deflowering or defruiting Average	-	-	98.44	-	-	136.63	-	-	105.83	

	Nitrogen (lbs/A)		
	50	100	150
Yield (Bushels/Acre)	77.25	102.29	161.14

L.S.D.	5%	1%
Between deflowering or defruiting averages	26.61	37.96
Between nitrogen averages	26.61	37.96
Between interactions (D x N x C)	86.87	115.24

levels of 500 and 1,000 pounds per acre a significant increase in the early yield was obtained when flower buds were removed before anthesis. When the plants were defruited a significant decrease in the early yield was obtained by raising the calcium rates from 0 to 500 pounds per acre.

As shown in Table 21, the raising of the levels of nitrogen from 50 to 150 pounds per acre resulted in a significant increase in the late yield of peppers irrespective of removal of flowers or fruits and no removal from the plant at the calcium rate of 500 pounds per acre. An increase in the level of calcium from 0 to 500 pounds per acre resulted in a decrease of late yield when the plants were defruited at an application of 50 pounds nitrogen per acre. When no calcium was applied and the flower buds were removed from the plants, the late yield was increased by increasing the nitrogen level from 50 to 150 pounds per acre.

Weight of Fruits per Plant: The data on the average weight of marketable fruits per plant are presented in Table 22. Raising the nitrogen level from 50 to 150 pounds per acre resulted in a positive linear response on the average weight of fruits produced per plant. There was an interaction between the calcium levels and deflowering or defruiting treatment. When no calcium was applied, the average weight of fruits of the defruited plants was significantly greater than from the plants where no treatment was made. The deflowered plants resulted in greater average weight of fruits than untreated plants when calcium was applied at the rate of 500 pounds per acre. There was no interaction of the other treatments on the average weight of fruits produced per plant.

TABLE 22

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE WEIGHT OF MARKETABLE PEPPER FRUITS PER PLANT--1961

Calcium Sulfate (lbs/A)	Nitrogen (lbs/A)			Deflowering or defruiting			Average
	50	100	150	Untreated	Deflowered	Defruited	
				Weight (lbs)			
0	0.72	1.02	1.17	0.72	0.94	1.25	0.97
500	0.69	0.91	1.32	0.72	1.25	0.95	0.97
1000	0.85	0.86	1.21	0.92	1.04	0.96	0.97
Average	0.74	0.93	1.24	0.78	1.08	1.05	0.97

L.S.D.	5%	1%
Between deflowering or defruiting averages	0.19	0.25
Between nitrogen averages	0.19	0.25
Between interaction (D x C)	0.33	0.45

TABLE 23

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE NUMBER OF PEPPER FRUITS EXHIBITING BLOSSOM-END ROT--1961

Calcium Sulfate (lbs/A)	Nitrogen (lbs/A)			Deflowering or defruiting			Average
	50	100	150	Untreated	Deflowered	Defruited	
				Number of fruits/Acre			
0	3,162	3,009	4,437	3,519	3,213	3,876	3,536
500	1,836	2,295	3,621	3,315	2,754	1,683	2,584
1000	1,836	2,754	2,295	2,499	2,754	1,632	2,295
Average	2,278	2,686	3,451	3,111	2,907	2,397	2,805

L.S.D.	5%	1%
Between Calcium sulfate averages	961	1,275
Between nitrogen levels	961	1,275

Blossom-End Rot: The results on the number of fruits affected with blossom-end rot, as associated with various treatments, are shown in Table 23. It is indicated that raising the level of nitrogen from 50 to 150 pounds per acre resulted in an increase of fruits exhibiting blossom-end rot. However, as the calcium sulfate levels were increased from 0 to 1,000 pounds per acre the number of blossom-end rot fruits was significantly reduced. There was no interaction among any of these treatments on the blossom-end rot of peppers. The deflowering or defruiting treatment did not reduce the number of affected fruit.

Sunburned Peppers: The data in Table 24 indicate that as the levels of nitrogen were raised from 50 to 150 pounds per acre there was a reduction in the number of sunburned fruits. The number of sunburned fruits obtained either from removing of flowers or from removing of fruits was significantly less than harvested from the normal flowering or fruiting plants. However, no difference was found in the number of sunburned fruits between deflowering and defruiting treatments. Calcium did not affect the number of sunburned fruits.

Chemical Deflowering and Defruiting

Naphthaleneacetic Acid (NAA)

The employment of NAA as a spray at concentrations tested had no effect on subsequent average plant height. However, as evidenced by the data in Table 25, it was found that NAA had a marked effect on the

TABLE 24

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN, AND CALCIUM ON THE NUMBER OF PEPPER FRUITS EXHIBITING SUNBURN--1961

Calcium Sulfate (lbs/A)	Nitrogen (lbs/A) 50	100	150	Deflowering or defruiting Untreated	Deflowered	Defruited	Average
				Number of fruits/acre			
0	6,783	4,896	3,927	6,222	5,196	3,468	5,202
500	6,426	4,947	4,080	7,140	3,723	4,590	5,151
1000	6,222	4,437	3,111	6,120	3,825	3,825	4,950
Average	6,477	4,760	3,706	6,477	4,488	3,927	4,981

L.S.D.	5%	1%
Between deflowering or defruiting averages	1,564	2,057
Between nitrogen averages	1,564	2,057

TABLE 25

EFFECT OF NAPHTHALENEACETIC ACID (NAA) ON ABSCISSION AND YIELD OF PEPPERS

Stage of application	Concentrations (Molar) 10^{-3}	10^{-4}	10^{-5}	10^{-6}	0	Average
	Average number of flowers undergoing abscission					
Pre-bloom	9	7	7	8	5	7
Bloom	12	17	9	12	5	11
Post-bloom	15	13	6	8	2	9
Average	12	12	8	10	4	9
	Average bushels per acre of U.S. Fancy fruits					
Pre-bloom	210.7	120.4	111.8	180.6	103.2	146.2
Bloom	154.8	296.7	266.6	154.8	141.9	202.1
Post-bloom	180.6	150.5	133.3	210.7	189.2	172.0
Average	180.6	189.2	172.0	180.6	146.2	173.6

	Abscission		Bushels/Acre	
L.S.D.	5%	1%	5%	1%
Between concentration averages	3	5	-	-
Between interactions (C x S)	-	-	119.7	159.9

flower abscission particularly at higher concentrations (10^{-3} and 10^{-4} Molar). All the concentrations of NAA ranging from 10^{-3} to 10^{-6} Molar resulted in an increased abscission of flowers as compared with control where no spraying of NAA was made. No differences in the number of flowers abscissed could be attributed to the stage of application. An interaction between concentrations of NAA and stages of application was found with the yield of U.S. Fancy peppers, as shown in Table 25. Concentrations of 10^{-4} and 10^{-5} Molar NAA produced a greater average yield of U.S. Fancy peppers when sprayed at the bloom stage in comparison to pre-bloom and post-bloom sprays. Increasing concentration from 0 to 10^{-4} Molar sprayed at bloom stage showed an increasing trend in yield of peppers with a depression at the higher concentration (10^{-3} Molar). Yields of other grades of peppers were not affected by the use of NAA.

Gibberellic Acid (GA)

It was observed in the field experiment that gibberellic acid did not have any effect on removing the flowers or fruits from the pepper plants but its effect on growth of plants was apparent. Although the tallest plants were obtained by spraying with GA at 10^{-2} Molar concentration as shown in Table 26, the leaves exhibited chlorotic regions on the blades. The increase in the average plant height due to 10^{-2} Molar concentration was significant as compared to the control and the lowest concentration (10^{-5} Molar) of gibberellic acid. The use of the several concentrations of gibberellic acid sprayed on the pepper plants did not affect the yield of fruits, a result similar to Ozaki (120).

TABLE 26

EFFECT OF GIBBERELLIC ACID (GA) ON THE AVERAGE HEIGHT (INCHES) OF PEPPER PLANTS

Stage of Application	Concentration (Molar)					Average
	10^{-2}	10^{-3}	10^{-4}	10^{-5}	0	
Pre-bloom	15.2	12.0	13.5	13.2	13.6	13.5
Bloom	16.7	14.7	13.0	12.7	12.4	13.9
Post-bloom	16.1	13.6	14.0	13.2	13.3	14.0
Average	15.0	13.4	13.5	13.0	13.1	13.8

L.S.D.	5%	1%
Between concentration averages	1.70	2.34

TABLE 27

EFFECT OF TRANS-CINNAMIC ACID ON THE AVERAGE HEIGHT (INCHES) OF PEPPER PLANTS

Stage of Application	Concentration (Molar)					Average
	10^{-4}	10^{-5}	10^{-6}	10^{-7}	0	
Pre-bloom	14.8	12.9	13.2	12.9	12.8	13.2
Bloom	12.9	13.0	11.7	14.2	12.6	12.9
Post-bloom	12.8	12.7	11.7	14.1	12.0	12.6
Average	13.5	12.8	12.2	13.6	12.5	12.7

L.S.D.	5%	1%
Between concentration averages	0.57	0.77

Trans-cinnamic Acid

The trans-cinnamic acid sprays had a significant effect on the average height of pepper plants as shown in Table 27. There was an increase in the height of plants by spraying trans-cinnamic acid at 10^{-7} Molar concentration, then a significant decrease in the average height of the plant as the concentrations were raised from 10^{-7} to 10^{-6} Molar followed by an increase at higher concentrations. Trans-cinnamic acid had no effect on the fruit yield of any grade of peppers.

Sodium 2,3-dichloroisobutyrate (FW-450)

The data on the average plant height of pepper plants and the yield of pepper fruits indicated that various concentrations of FW-450 had no significant effect. However, the treated plants in the field appeared to be more vigorous. Some effects on abscission were noticed at 0.35 per cent, the higher concentration used. Consequently, additional concentrations including 0.5, 1.0, 1.5, and 2.0 per cent FW-450 were tried on the guard rows. It was observed that with concentrations of 1.5 and 2.0 per cent the plants were completely killed. At 1.0 per cent concentrations, both survival of some leaves and complete abscission of flowers and fruits was noted. However, at 0.5 per cent concentration, the plants were completely deflowered without any injurious effect to the foliage (Fig. 4).

Soil Tests

The results on the chemical analysis of the soil samples taken during the course of field experiments in 1960 and 1961 are presented in the appendix in Tables 46 through 50.

Fig. 4. Effect of sodium 2,3-dichloroisobutyrate on deflowering and defruiting of Yolo Wonder pepper plants

The initial soil samples in 1960, as analyzed for total nitrogen, showed variations which may account for the differences in the yield of pepper fruits as influenced by the levels of nitrogen.

The initial samples analyzed for the average pH and available nutrients such as P_2O_5, K_2O, MgO and CaO indicated that the experimental fields were quite uniform in both years with little variation in the natural soil fertility.

In 1960, the results of the analysis of the soil samples at the termination of the experiment, in general, indicated an increase in the average P_2O_5 and MgO and a decrease in the average K_2O, and CaO contents. In 1961, the samples taken at the end of the experiment indicated an increase in the average P_2O_5, K_2O, MgO and CaO contents, while the pH of the soil was decreased as compared with the initial samples.

The results of the final samples in 1960, and interim and final samples in 1961 were analyzed statistically. Such analyses were made to determine if the existing treatments had any pronounced direct or indirect effects on the amount of the available soil nutrients. These analyses showed that several interaction effects of the treatments were associated with the contents of the available nutrients in the soil. However, no effort was made to explain these differences because it was felt that the variations were not due entirely to the treatments of plants and the soil. The variations observed may also have been due to several factors such as: (1) individual plot soil heterogeniety which may have erroneously permitted such treatments, as variety or deflowering and defruiting treatments to affect the level of soil

nutrients; (2) mechanical disturbances in the soil during cultural operations; (3) soil sampling errors; and (4) errors in the chemical analysis of the samples, for example, preparation of samples for analysis and various interferences in the use of flame spectrophotometer for chemical analysis.

Foliar Composition

Greenhouse Experiment.--Mature leaf samples were taken on December 11, 1960 from the greenhouse experiment No. 5 and analyzed for various mineral elements. The analysis of the leaves for per cent total nitrogen and potassium indicated that levels of nitrogen, phosphorus and potash, supplied to the pepper plants grown in the pots had no effect on these elements (Table 28).

The data in Table 29, however, indicate that increasing the level of phosphorus in the substrate from 100 to 200 pounds per acre resulted in a significant increase in the phosphorus content of the pepper leaves. There was no effect of nitrogen and potash levels on the amount of phosphorus in the tissue.

Significant differences in the per cent magnesium content of the pepper leaves as affected by nitrogen, phosphorus and potash levels are shown in Table 30. Raising the potash level from 100 to 200 pounds per acre in the pots resulted in a significant decrease in the per cent magnesium at the 100 pounds level of phosphorus when the rates of nitrogen application were 100 and 150 pounds per acre.

The sodium content of the pepper leaves was significantly influenced by an interaction of nitrogen, phosphorus and potash levels

TABLE 28

EFFECT OF NITROGEN, PHOSPHORUS AND POTASH LEVEL ON THE AVERAGE PER CENT NITROGEN AND POTASSIUM CONTENT OF PEPPER LEAVES

Potash (lbs/A)	Nitrogen (lbs/A) 50		100		150		Average
	Phosphorus (lbs/A) 100	200	100	200	100	200	
			Nitrogen				
100	5.15	5.59	4.82	5.38	4.39	4.83	5.02
200	4.95	4.93	4.38	5.15	5.04	5.05	4.98
Average	5.05	5.26	4.43	5.26	4.72	4.77	5.00
			Potassium				
100	6.71	6.77	6.78	7.08	6.57	6.61	6.75
200	6.66	6.92	7.04	6.80	6.65	6.85	6.82
Average	6.68	6.84	6.91	6.94	6.61	6.73	6.78

L.S.D. Not significant

TABLE 29

EFFECT OF PHOSPHORUS AND POTASH LEVELS
ON THE AVERAGE PER CENT PHOSPHORUS
CONTENT OF THE PEPPER LEAVES

Phosphorus (lbs/A)	Potash (lbs/A) 100	200	Average
100	0.213	0.220	0.217
200	0.293	0.298	0.296
Average	0.253	0.259	0.257
L.S.D.		5%	1%
Between phosphorus averages		0.052	0.071

TABLE 30

EFFECT OF NITROGEN, PHOSPHORUS AND POTASH LEVELS
ON THE AVERAGE PER CENT MAGNESIUM CONTENT
IN THE PEPPER LEAVES

	Nitrogen (lbs/A)						
	50		100		150		
Potash	Phosphorus (lbs/A)						
(lbs/A)	100	200	100	200	100	200	Average
100	0.61	0.49	0.73	0.71	0.90	0.78	0.70
200	0.59	0.41	0.57	0.73	0.66	0.76	0.62
Average	0.60	0.45	0.65	0.72	0.78	0.77	0.66
Nitrogen averages		0.53		0.69		0.78	

	5%	1%
L.S.D.		
Between nitrogen averages	0.08	0.11
Between potash averages	0.06	0.08
Between interactions (N x P)	0.12	0.17
Between interactions (N x P x K)	0.16	0.22

(Table 31). An increase in the amount of sodium in the pepper leaves was obtained at each level of phosphorus when the rates of nitrogen were raised from 50 to 150 pounds per acre. As the potash levels were increased from 100 to 200 pounds per acre there was a significant decrease in the sodium content of the pepper leaves at 100 pounds phosphorus level when nitrogen was applied at the rate of 50 pounds per acre.

As shown in Table 32, the amount of calcium in the leaves was increased significantly by raising the phosphorus level from 100 to 200 pounds per acre when nitrogen and potash were applied at 50 and 100 pounds rates respectively.

Field Experiment, 1960.--In the field experiment begun in the Spring of 1960, mature leaf samples were taken on July 11, 1960 and analyzed for the sugar and mineral elements. The results of this analysis are presented as follows:

Sugars: In 1960 leaf samples of only one variety, Florida Giant, were analyzed for reducing and total sugars. Results in Table 33 showed that there was no effect of nitrogen and deflowering or defruiting treatments on the reducing and total sugar content in the pepper leaves. However, the data do suggest further tests.

Mineral Elements: Mineral elements analyzed in this test were total nitrogen, phosphorus, potassium, magnesium and calcium. It can be seen from the data presented in Table 34 that the average total nitrogen and potassium contents of the leaves were not affected by the treatments tested in the experiment. Similarly no effects of the treatments were found on the average percentages of the phosphorus in the leaves as

TABLE 31

EFFECT OF NITROGEN, PHOSPHORUS AND POTASH LEVELS
ON THE AVERAGE PER CENT SODIUM CONTENT
IN THE PEPPER LEAVES

Potash	Nitrogen (lbs/A)						
	50		100		150		
	Phosphorus (lbs/A)						
(lbs/A)	100	200	100	200	100	200	Average
100	0.117	0.060	0.150	0.073	0.173	0.186	0.126
200	0.066	0.063	0.156	0.063	0.153	0.183	0.114
Average	0.092	0.062	0.153	0.068	0.163	0.185	0.120
Nitrogen averages		0.072		0.110		0.174	
			Phosphorus (lbs/A)				
			100	200			
Averages for per cent sodium			0.136	0.105			

L.S.D.	5%	1%
Between nitrogen averages	0.008	0.011
Between phosphorus averages	0.021	0.028
Between interactions (N x P)	0.012	0.017
Between interactions (N x P x K)	0.049	0.067

TABLE 32

EFFECT OF NITROGEN, PHOSPHORUS AND POTASH LEVELS
ON THE AVERAGE PER CENT CALCIUM CONTENT
IN THE PEPPER LEAVES

Potash	Nitrogen (lbs/A)						
	50		100		150		
	Phosphorus (lbs/A)						
(lbs/A)	100	200	100	200	100	200	Average
100	1.40	0.85	1.00	1.08	1.29	1.71	1.22
200	1.14	0.75	0.92	1.11	1.10	1.30	1.05
Average	1.27	0.80	0.96	1.09	1.19	1.50	1.14

L.S.D.	5%	1%
Between interactions (N x P)	0.45	0.62
Between interactions (N x P x K)	0.41	0.56

TABLE 33

EFFECT OF DEFLOWERING OR DEFRUITING AND NITROGEN ON AVERAGE PER CENT REDUCING AND TOTAL SUGAR CONTENT IN PEPPER LEAVES ON JULY 11, 1960

Nitrogen (lbs/A)	Deflowering or defruiting			Average
	Untreated	Deflowered	Defruited	
		Reducing sugar		
100	0.74	0.88	0.86	0.83
150	0.74	0.63	0.78	0.72
200	0.78	0.74	0.71	0.74
Average	0.75	0.75	0.78	0.77
		Total sugar		
100	1.40	1.75	1.40	1.51
150	0.88	1.34	1.51	1.24
200	1.40	1.05	1.29	1.24
Average	1.22	1.38	1.40	1.33

L.S.D. Not significant

TABLE 34

EFFECT OF VARIETY, DEFLOWERING OR DEFRUITING AND NITROGEN ON THE AVERAGE PER CENT TOTAL NITROGEN AND POTASSIUM CONTENTS IN PEPPER LEAVES ON JULY 11, 1960

Nitrogen (lbs/A)	Deflowering or defruiting			Variety			Average
	Untreated	Deflowered	Defruited	Florida Giant	Yolo Wonder	California Wonder	
			Total nitrogen				
100	4.82	4.82	4.82	4.57	4.88	4.80	4.82
150	4.83	4.76	4.95	4.57	4.86	4.82	4.84
200	4.60	4.68	4.95	4.76	4.91	5.04	4.75
Average	4.75	4.75	4.91	4.63	4.88	4.89	4.80
			Potassium				
100	7.73	7.08	7.12	7.58	7.14	7.02	7.31
150	6.83	7.18	6.84	7.61	7.13	6.87	6.95
200	7.18	7.35	7.91	7.34	7.13	7.39	7.47
Average	7.24	7.20	7.29	7.51	7.13	7.09	7.25

L.S.D. Not significant

evidenced by the data in Table 35. However, an interaction of variety with nitrogen was found to occur on the average magnesium content of the pepper leaves. In the samples of leaves from the variety Florida Giant, a significant decrease in the magnesium content was obtained when the nitrogen levels were increased above 150 pounds per acre in the soil.

Calcium content of the pepper leaves was affected by the interactions of variety with the levels of nitrogen and variety with the treatments involving deflowering or defruiting as shown in Tables 36 and 37. The leaf samples of variety Florida Giant showed increased amount of calcium by raising the level of nitrogen in the soil from 100 to 150 pounds per acre and then decreased at the highest level (200 pounds per acre). An increase in the calcium content of the pepper leaves was obtained with the variety California Wonder as the nitrogen levels were increased from 100 to 200 pounds per acre. When 100 and 150 pounds of nitrogen were applied uniformly to the plants of all varieties, it was found that the leaves of the variety Florida Giant contained significantly higher amount of calcium in comparison with the leaves of varieties Yolo Wonder and California Wonder. There was also an interaction of the varieties with the treatment of deflowering or defruiting. The average calcium content of the leaves of the Florida Giant variety were higher than Yolo Wonder leaves regardless of whether the plants were deflowered or defruited or not treated. However, the calcium content of the pepper leaves of the variety California Wonder did not differ from either Florida Giant or Yolo Wonder except where

TABLE 35

EFFECT OF VARIETY, DEFLOWERING OR DEFRUITING AND NITROGEN ON THE AVERAGE PER CENT PHOSPHORUS AND MAGNESIUM CONTENT IN PEPPER LEAVES ON JULY 11, 1960

Nitrogen (lbs/A)	Deflowering or defruiting			Variety			Average
	Untreated	Deflowered	Defruited	Florida Giant	Yolo Wonder	California Wonder	
				Phosphorus			
100	0.46	0.47	0.46	0.45	0.46	0.45	0.46
150	0.45	0.46	0.45	0.43	0.44	0.47	0.45
200	0.45	0.44	0.45	0.44	0.46	0.46	0.45
Average	0.45	0.46	0.45	0.44	0.45	0.46	0.45
				Magnesium			
100	1.07	1.05	1.18	1.11	0.94	0.95	1.10
150	0.95	1.04	0.98	1.18	1.06	0.97	0.99
200	0.98	1.11	0.94	0.91	1.07	1.10	1.00
Average	1.00	1.07	1.03	1.06	1.02	1.01	1.03

L.S.D.	Phosphorus 5%	Phosphorus 1%	Magnesium 5%	Magnesium 1%
Between interactions (V x N)	-	-	0.26	0.31

TABLE 36

EFFECT OF VARIETY, DEFLOWERING OR DEFRUITING AND NITROGEN ON AVERAGE PER CENT CALCIUM CONTENT IN PEPPER LEAVES ON JULY 11, 1960

Nitrogen (lbs/A)	Deflowering or defruiting			Variety			Average
	Untreated	Deflowered	Defruited	Florida Giant	Yolo Wonder	California Wonder	
100	2.66	2.48	2.63	2.56	2.30	2.33	2.39
150	2.26	2.68	2.48	2.96	2.33	2.50	2.59
200	2.28	2.63	2.51	2.58	2.43	2.60	2.53
Average	2.59	2.47	2.47	2.70	2.36	2.48	2.51

L.S.D.	5%	1%
Between variety averages	0.13	0.18
Between nitrogen averages	0.13	0.18
Between interactions (V x N)	0.22	0.29

TABLE 37

EFFECT OF VARIETY AND DEFLOWERING OR DEFRUITING INTERACTION ON AVERAGE PER CENT CALCIUM CONTENT IN PEPPER LEAVES ON JULY 11, 1960

Deflowering or defruiting	Variety			Average
	Florida Giant	Yolo Wonder	California Wonder	
Untreated	2.71	2.48	2.58	2.59
Deflowered	2.65	2.30	2.46	2.47
Defruited	2.74	2.28	2.39	2.47
Average	2.70	2.36	2.48	2.51

L.S.D.	5%	1%
Between variety averages	0.13	0.18
Between interaction (V x D)	0.22	0.29

the plants were defruited. Florida Giant contained more calcium in the leaves than California Wonder (Table 37).

Field Experiment, 1961.--In the field experiment of 1961 samplings of the pepper leaves were made at two dates (July 6 and August 1) during the growing season. The samples were analyzed for the sugar contents and the various mineral elements. The results of the analysis are presented as follows:

Reducing Sugars: In the leaf samples taken on July 6, 1961 there was an increase in the reducing sugar content by removing the flower buds as compared with the plants where no removal was made (Table 38). The average per cent of reducing sugar from the former treatment was not significantly different as compared with the plants from which young developing fruits were removed. Although the levels of nitrogen and calcium had no independent responses on reducing sugar content, an interaction of these two factors was found. An increase in the level of calcium sulfate from 0 to 1,000 pounds per acre resulted in an increase in the reducing sugar content of the leaves when nitrogen was applied at the rate of 150 pounds per acre. When no calcium was applied there was a significant decrease in the reducing sugar by increasing the level of nitrogen from 50 to 100 pounds per acre. At 1,000 pounds level of calcium sulfate, the reducing sugar content was reduced by increasing the nitrogen application from 100 to 150 pounds per acre.

The leaf samples taken at the termination (August 1, 1961) of the experiment showed (Table 38) that by increasing the level of calcium

TABLE 38

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON AVERAGE PER CENT REDUCING SUGAR IN THE PEPPER LEAVES--1961

Calcium Sulfate (lbs/A)	Nitrogen (lbs/A)			Deflowering or defruiting			Average
	50	100	150	Untreated	Deflowered	Defruited	
				Sampling July 6			
0	1.26	0.99	1.19	1.05	1.13	1.25	1.15
500	1.10	1.16	1.13	1.05	1.28	1.06	1.13
1000	1.09	1.18	0.86	0.81	1.25	1.09	1.05
Average	1.15	1.11	1.07	0.97	1.22	1.14	1.11
				Sampling August 1			
0	0.66	0.71	0.61	0.68	0.69	0.60	0.66
500	0.53	0.64	0.64	0.61	0.64	0.54	0.60
1000	0.73	0.60	0.56	0.59	0.60	0.71	0.63
Average	0.65	0.64	0.60	0.63	0.64	0.62	0.63

	Sampling July 6		Sampling August 1	
L.S.D.	5%	1%	5%	1%
Between deflowering or defruiting averages	0.17	0.24	-	-
Between interactions (N x C)	0.21	0.42	0.05	0.08

from 0 to 500 pounds per acre, the sugar content was decreased with an increase at the 1,000 pounds level when nitrogen was applied at the rate 50 pounds per acre. At 100 pounds nitrogen level, the raising of calcium from 0 to 500 pounds per acre decreased the reducing sugar content. At 150 pounds nitrogen rate an increase in the calcium level from 500 to 1,000 pounds per acre decreased the reducing sugar content of the pepper leaves.

Total Sugar: There was no difference in the average total sugar content of the pepper leaves sampled on July 6, 1961 as a result of various deflowering or defruiting treatments (Table 39). However, there was an interaction between the levels of calcium and nitrogen. Increasing the level of calcium from 0 to 1,000 pounds per acre resulted in a quadratic response when the nitrogen was applied at the rate of 50 pounds per acre with less total sugar being found at the highest rate (1,000 pounds) of calcium.

In the final leaf samples (August 1, 1961) the total sugar content was affected by an interaction of deflowering or defruiting with the levels of calcium (Table 39). When the pepper plants were defruited, an increase in the level of calcium from 0 to 1,000 pounds per acre resulted in a linear increase in the total sugar content of the pepper leaves. At 1,000 pounds level of calcium, the leaves from the defruited plants contained higher amount of sugar in comparison to the leaves from deflowered plants.

Total Nitrogen: By the data in Table 40, it is indicated that when the leaves were sampled on July 6, 1961, raising the nitrogen

TABLE 39

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON AVERAGE PER CENT TOTAL SUGAR IN THE PEPPER LEAVES--1961

Calcium Sulfate (lbs/A)	Nitrogen (lbs/A)			Deflowering or defruiting			Average
	50	100	150	Untreated	Deflowered	Defruited	
				Sampling July 6			
0	3.64	2.54	3.26	2.97	3.15	3.32	3.15
500	3.87	2.91	3.06	3.90	3.93	3.00	3.61
1000	2.60	3.44	3.58	3.15	3.18	3.29	3.21
Average	3.37	3.29	3.30	3.34	3.43	3.20	3.32
				Sampling August 1			
0	4.79	4.02	4.28	4.20	5.04	3.84	4.36
500	4.31	4.35	4.02	3.91	3.62	5.15	4.23
1000	4.79	4.16	5.81	4.97	3.51	6.28	4.92
Average	4.63	4.18	4.70	4.36	4.06	5.09	4.47

	Sampling July 6		Sampling August 1	
L.S.D.	5%	1%	5%	1%
Between interaction (N x C)	1.17	1.53	-	-
Between interaction (D x C)	-	-	1.83	2.42

TABLE 40

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE PER CENT TOTAL NITROGEN IN PEPPER LEAVES--1961

Nitrogen (lbs/A)	Deflowering or defruiting: Untreated			Deflowered			Defruited			Average
	Calcium sulfate (lbs/A): 0	500	1000	0	500	1000	0	500	1000	
Sampling July 6										
50	3.29	2.50	2.69	2.50	2.96	2.99	3.42	2.86	3.27	2.95
100	3.89	3.49	2.63	3.81	3.52	3.36	3.78	3.42	3.06	3.33
150	3.06	3.88	3.51	4.24	3.32	3.42	3.85	2.93	3.72	3.55
Average	3.08	3.29	2.94	3.52	3.26	3.26	3.68	3.07	3.35	3.27
Sampling August 1										
50	2.47	2.11	2.57	2.70	3.22	2.93	2.89	2.50	3.78	2.79
100	2.37	2.79	3.03	3.19	3.22	3.16	2.76	2.40	2.84	2.86
150	3.22	2.66	3.23	3.32	3.35	2.93	3.03	2.73	2.79	3.03
Average	2.68	2.52	2.94	3.07	3.27	3.00	2.89	2.54	3.14	2.89
Averages for deflowering or defruiting	-	-	2.72	-	-	3.12	-	-	2.86	

L.S.D.	Sampling July 6 5%	Sampling July 6 1%	Sampling August 1 5%	Sampling August 1 1%
Between nitrogen averages	0.37	0.51	-	-
Between deflowering or defruiting averages	-	-	0.29	0.39

level from 50 to 150 pounds per acre resulted in a linear increase in the total nitrogen content of the tissue. The treatment of deflowering or defruiting and levels of calcium had no effect on the average nitrogen content of the pepper leaves. However, at the termination of the experiment on August 1, 1961 the total nitrogen content of the leaves of deflowered plants was significantly higher than the leaves of the plants where the flowering and fruiting was allowed to occur in the normal course. The nitrogen content of the leaves of defruited plants was not different from that found in either the deflowered or untreated plants. There was no effect of calcium and nitrogen levels on the average per cent total nitrogen in the leaves of pepper plant at the end of the experiment as shown in Table 40.

Phosphorus: In the leaves of the samples taken on July 6, 1961 the phosphorus content was significantly influenced by the interactions of all treatments (Table 41). An increase in the average phosphorus content of the leaves was obtained by raising the calcium level from 0 to 1,000 pounds per acre when the nitrogen was applied at the rate of 50 pounds per acre and no flowers or fruits were removed from the pepper plants. When no calcium was applied and no removal of flowers or fruits was made, raising the nitrogen level from 50 to 100 pounds per acre resulted in an increase of the phosphorus in the leaves. An increase in the calcium levels from 500 to 1,000 pounds per acre resulted in a significant increase in phosphorus at 100 pounds nitrogen level when the flower buds were removed. A decrease in the phosphorus content was observed by increasing the nitrogen level from 50 to 150 pounds per acre

TABLE 41

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON AVERAGE PER CENT PHOSPHORUS CONTENT IN PEPPER LEAVES--1961

Calcium sulfate (lbs/A)	Deflowering or defruiting: Untreated			Deflowered			Defruited			
	Nitrogen (lbs/A): 50	100	150	50	100	150	50	100	150	Average
				Sampling July 6						
0	0.10	0.18	0.12	0.10	0.14	0.14	0.15	0.12	0.16	0.13
500	0.15	0.13	0.11	0.10	0.12	0.11	0.12	0.10	0.15	0.12
1000	0.19	0.14	0.11	0.12	0.19	0.11	0.16	0.10	0.15	0.14
Average	0.14	0.15	0.11	0.11	0.15	0.12	0.14	0.11	0.15	0.13
				Sampling August 1						
0	0.11	0.20	0.17	0.14	0.12	0.18	0.27	0.25	0.13	0.18
500	0.17	0.18	0.12	0.15	0.18	0.12	0.15	0.15	0.22	0.16
1000	0.19	0.18	0.14	0.15	0.20	0.15	0.15	0.22	0.17	0.17
Average	0.16	0.19	0.14	0.15	0.17	0.16	0.20	0.20	0.19	0.17
Average for deflowering or defruiting	-	-	0.16	-	-	0.16	-	-	0.20	0.17

L.S.D.	Sampling July 6 5%	Sampling July 6 1%	Sampling August 1 5%	Sampling August 1 1%
Between deflowering or defruiting averages	-	-	0.03	0.04
Between interactions (D x N)	0.03	0.05	-	-
Between interactions (D x N x C)	0.06	0.08	0.07	0.10

when the calcium was applied at 1,000 pounds rate and no deflowering or defruiting treatment was made to the pepper plants. On the other hand when the flower buds were removed from the plants there was an increase in the phosphorus content of the leaves by increasing the nitrogen level from 50 to 100 pounds per acre and a decrease at the 150 pounds nitrogen level when the calcium was applied at the rate of 1,000 pounds per acre.

In the samples of August 1, 1961, as the levels of calcium applied to the soil were raised from 0 to 1,000 pounds per acre, an increase in the phosphorus content of the leaves was obtained when the nitrogen was applied at the rate of 50 pounds per acre with no flower or fruit removal and at 100 pounds per acre when the flower buds were removed. When the removal of young developing fruit was made, there was a decrease in the phosphorus content at the 50 pounds nitrogen level when the calcium level was raised from 0 to 500 pounds per acre.

Potassium: As shown in Table 42, there was a linear reduction in the amount of potassium in the leaves sampled on July 6, as the levels of nitrogen were raised from 50 to 150 pounds per acre to the no removal plots and no calcium was applied to the plots of deflowered plants. Such reduction of potassium in the leaves was not found in plants supplied with 1,000 pounds per acre of calcium regardless of treatments involving flower or fruit removal.

At the termination of the experiment (August 1), when no deflowering or defruiting treatments were made to the pepper plants, a quadratic response was obtained in the potassium content of the leaves at the level of 500 pounds calcium per acre by raising the nitrogen application rate

TABLE 42

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE PER CENT POTASSIUM IN THE PEPPER LEAVES--1961

Nitrogen (lbs/A)	Deflowering or defruiting									
	Untreated			Deflowered			Defruited			
	Calcium sulfate (lbs/A)									
	0	500	1000	0	500	1000	0	500	1000	Average
Sampling July 6										
50	6.14	6.59	6.53	6.60	5.49	5.79	6.62	6.74	6.39	6.32
100	5.78	5.81	6.33	5.94	6.29	5.79	6.08	6.68	5.81	6.06
150	6.00	5.28	6.85	5.34	5.72	6.35	5.63	5.77	6.45	5.93
Average	5.97	5.28	6.57	5.96	5.83	5.97	6.11	6.39	6.22	6.10
Sampling August 1										
50	5.70	6.17	6.14	5.91	5.27	5.84	5.64	5.72	6.30	5.85
100	5.85	6.35	5.68	5.35	5.69	5.68	5.82	5.41	5.35	5.69
150	5.44	5.16	5.82	5.22	6.06	4.91	5.61	4.73	5.72	5.41
Average	5.66	5.89	5.88	5.49	5.67	5.48	5.69	5.29	5.79	5.65

L.S.D.	Sampling July 6		Sampling August 1	
	5%	1%	5%	1%
Between nitrogen averages	0.29	0.39	-	-
Between interactions (D x N x C)	1.09	1.45	0.80	1.06

from 50 to 150 pounds per acre. When the plants were deflowered and defruited there was a quadratic response in the potassium content of leaves by increasing the calcium level from 0 to 1,000 pounds per acre with the nitrogen applied at 150 pounds per acre. The untreated plants contained a higher average percentage of potassium in the leaves than the deflowered ones when the calcium and nitrogen were applied to the soil at the rates of 500 and 50 pounds per acre, respectively. At 100 pounds nitrogen level when the calcium was applied at the rate of 500 pounds per acre, the untreated plants were significantly higher in potassium than defruited plants. Deflowered plants contained higher amounts of potassium in the leaves than untreated plants when calcium application was made at 500 pounds with the nitrogen at the rate of 150 pounds per acre. However, at 1,000 pounds level of calcium the deflowered plants contained less potassium than undeflowered or undefruited plants (Table 42).

Calcium: The interaction of all treatments tested and their effect on the average calcium content of the pepper leaves are shown in Table 43. In the data from the sampling of July 6, it is indicated that raising the level of nitrogen from 50 to 150 pounds per acre caused an increase in the calcium content of pepper leaves when the deflowered plants were growing in plots which had received no calcium or calcium at a rate of 1,000 pounds per acre. Similar increases occured with the defruited plants when supplied with 500 pounds of calcium per acre. However, the calcium content of the leaves of untreated plants was significantly increased by raising the nitrogen level from 50 to 100 pounds per acre at the calcium level of 500 pounds. At 50 pounds nitrogen level, an

TABLE 43

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE PER CENT CALCIUM IN THE PEPPER LEAVES--1961

Nitrogen (lbs/A)	Deflowering or defruiting: Untreated			Deflowered			Defruited			Average
	Calcium sulfate (lbs/A): 0	500	1000	0	500	1000	0	500	1000	
	Sampling July 6									
50	1.32	1.27	1.50	0.83	1.40	1.29	1.33	1.07	1.36	1.26
100	1.57	1.77	1.83	1.41	1.65	1.49	1.75	1.78	1.44	1.63
150	1.72	1.76	1.82	1.78	1.61	1.84	1.56	2.15	1.75	1.62
Average	1.53	1.60	1.72	1.34	1.56	1.54	1.55	1.67	1.51	1.56
	Sampling August 1									
50	0.69	0.76	1.01	0.69	1.06	1.03	0.85	0.66	1.04	0.86
100	1.36	1.32	1.58	1.41	1.32	1.40	1.33	1.25	1.01	1.33
150	1.43	1.92	1.32	1.55	1.21	1.58	1.29	1.49	1.37	1.77
Average	1.60	1.33	1.31	1.22	1.19	1.34	1.16	1.33	1.14	1.32

	Sampling July 6	
L.S.D.	5%	1%
Between nitrogen averages	0.17	0.22
Between interactions (D x N x C)	0.49	0.66

increase in the level of calcium from 0 to 500 pounds per acre resulted in an increase of the calcium content of the leaves when the pepper plants were deflowered.

The calcium content of the pepper leaves was not significantly affected by the various treatments as found in the final samples (August 1) of the pepper leaves (Table 43).

Magnesium: The magnesium content of pepper leaves was influenced by the levels of nitrogen and calcium and their interaction with deflowering or defruiting treatment as shown in Table 44. The data from the first sampling (July 6) revealed that the magnesium content of the leaves was increased by increasing the nitrogen rate from 50 to 150 pounds per acre when no calcium was applied to the plots of deflowered plants and when 500 pounds per acre of calcium was supplied to the defruited plants.

The final samples (August 1) indicated an increase in the magnesium percentage of leaves as the nitrogen levels were raised from 50 to 100 pounds per acre when no flower or fruit removal was made at a 500 pounds level of calcium. Similar increases were obtained with the deflowered plants when no calcium was supplied and with the defruited plants receiving calcium at the rate of 500 pounds per acre. At the 150 pounds nitrogen level when the plants were deflowered, there was a reduction in the magnesium content of the pepper leaves by raising the calcium rates from 0 to 1,000 pounds per acre.

Sodium: In the pepper leaf samples taken on July 6, the sodium content was significantly increased by increasing the rates of nitrogen

TABLE 44

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE PER CENT MAGNESIUM IN PEPPER LEAVES--1961

Nitrogen (lbs/A)	Deflowering or defruiting: Untreated			Deflowered			Defruited			Average
	Calcium sulfate (lbs/A): 0	500	1000	0	500	1000	0	500	1000	
Sampling July 6										
50	0.490	0.415	0.595	0.290	0.520	0.645	0.380	0.360	0.485	0.464
100	0.430	0.505	0.660	0.490	0.475	0.550	0.655	0.545	0.575	0.543
150	0.740	0.605	0.740	0.825	0.620	0.610	0.450	0.840	0.690	0.680
Average	0.553	0.508	0.665	0.535	0.538	0.601	0.495	0.582	0.583	0.562
Sampling August 1										
50	0.310	0.160	0.260	0.170	0.280	0.230	0.190	0.130	0.290	0.230
100	0.260	0.360	0.430	0.340	0.310	0.380	0.460	0.340	0.280	0.340
150	0.490	0.630	0.450	0.710	0.480	0.410	0.360	0.490	0.400	0.480
Average	0.350	0.380	0.380	0.410	0.340	0.360	0.330	0.320	0.330	0.350

	Calcium sulfate (lbs/A)		
	0	500	1000
	Per cent magnesium		
Sampling July 6	0.528	0.543	0.617

L.S.D.	Sampling July 6		Sampling August 1	
	5%	1%	5%	1%
Between nitrogen averages	0.083	0.110	0.070	0.090
Between calcium averages	0.083	0.110	-	-
Between interactions (D x N x C)	0.378	0.501	0.210	0.280

from 50 to 150 pounds per acre and the rates of calcium from 0 to 1,000 pounds per acre. This increase resulted in a linear fashion as shown in Table 45. The treatments tested did not have any significant effect on the sodium content of pepper leaves in the final samples taken at the termination of the experiment on August 1, 1961.

TABLE 45

EFFECT OF DEFLOWERING OR DEFRUITING, NITROGEN AND CALCIUM ON THE AVERAGE PER CENT SODIUM IN THE PEPPER LEAVES--1961

Nitrogen (lbs/A)	Deflowering or defruiting: Untreated			Deflowered			Defruited			Average
	Calcium sulfate (lbs/A): 0	500	1000	0	500	1000	0	500	1000	
Sampling July 6										
50	0.033	0.028	0.030	0.033	0.030	0.045	0.030	0.030	0.040	0.033
100	0.045	0.048	0.068	0.033	0.048	0.038	0.040	0.063	0.040	0.047
150	0.050	0.053	0.065	0.048	0.038	0.055	0.043	0.063	0.065	0.053
Average	0.043	0.043	0.054	0.038	0.038	0.046	0.038	0.052	0.048	0.044
Sampling August 1										
50	0.035	0.033	0.040	0.048	0.047	0.040	0.055	0.043	0.032	0.041
100	0.048	0.045	0.045	0.032	0.043	0.050	0.043	0.040	0.045	0.043
150	0.043	0.055	0.055	0.073	0.050	0.048	0.048	0.048	0.060	0.053
Average	0.042	0.044	0.047	0.051	0.047	0.046	0.048	0.043	0.046	0.047

	Calcium sulfate (lbs/A)		
	0	500	1000
	Per cent Sodium		
Sampling July 6	0.039	0.044	0.049

	Sampling July 6	
L.S.D.	5%	1%
Between nitrogen averages	0.008	0.011
Between calcium averages	0.008	0.011

DISCUSSION

Growth Responses

In both the greenhouse and field experiments of this investigation a greater increase in the height of the pepper plants was obtained when the flower buds, opened flowers and young developing fruits were removed from the plants as compared to the plants where no such treatments were made. The plant height of some varieties was greater than others and the varieties differed in their interactions with cultural treatments. This differential superiority of one variety over another is believed to be based purely on their genetic characteristics (46, 52, 55, 70, 79, 139).

It may be worthwhile to describe briefly the growth behavior of the pepper plant before discussing the effect of deflowering and defruiting. The pepper plant normally grows with a single stem until about 8-12 leaves have been formed. The main stem then terminates with a flower. Two (or sometimes more than two) branches grow from the axils of the highest leaves. Each of these branches forms two leaves and terminates in a flower. Thus a repeated seemingly dichotomous branching is obtained and the whole plant assumes an inverted conical shape.

The findings of the experiments conducted indicate that the growth of the pepper plants is associated with the presence of flowers or fruits which restrict the growth and consequently results in a serious condition of stunting. The plant apparently assumes its natural growth habits,

as described before, regardless of initial flower or fruit removal. However, the fact that the plant heights are greatly increased by the deflowering or defruiting treatment in comparison to normal growth needs further explanation. This may be explained by two possible reasons. First, the flower buds may have a growth inhibiting substance present or the developing ovary may produce an inhibitor. Also, the nutritional food material may be utilized primarily in the growth and development of the fruit thereby restricting the vegetative growth (8, 52, 85, 115, 173, 175).

The results of deflowering treatments on Vicia faba by Mattirolo (97), Sea Island Cotton by Mason (95), tomato by Watts (174) and Miller (103) are in close agreement with the results of pepper experiments in this investigation. It was shown by each of these workers that the initial removal of flowers resulted in vigorous vegetative growth accompanied by plant height.

Murneek (106), working with tomato, reported that vegetative growth was regulated or controlled by the fruit. He found that decrease of nitrogen in the soil or of the stored nitrogen in the plant tends to retard development. The fruit seemed to be able to monopolize practically all of the elaborated nitrogen which caused a shortage in the strictly vegetative parts of the plant. Although, the developing fruits retarded the vegetative growth, fertilization or the gametic union stimulated vegetative growth. This stimulation seems to affect the whole plant as well as the tissues surrounding the embryos. In Murneek's studies, plants from which the flowers were removed prior to fertilization made

less growth than did those whose fruits were removed soon after they were set. However, McCollum (99) reported that cucumber plants were invariably inhibited by one fertilized fruit and complete cessation of growth resulted from an increased inhibitive influence. He postulated that developing fertilized ovary produces a growth regulating substance.

The effects of fruit removal in these studies are certainly in agreement with McCollum's work. However, the removal of flowers or fruit have different effects than stated by Murneek (106). In both 1960 and 1961, plants from which flowers were removed before fertilization, made more growth than those which were defruited. However, both treatments resulted in a greater plant height than untreated plants.

The inhibitive influence of the flower bud on the vegetative growth can possibly be explained on the basis of the phenomenon of "apical dominance" (20). The position of apical bud in "apical dominance" resembles in many ways the relation of auxin-mediated elongation in the growing region of the stem. Thus, the inhibition of growth by apical bud, in general, is a polar phenomenon. The inhibiting influence moves downward from the apical bud readily enough, but cannot move upward through the stem. The fact that the apical dominance is dependent on the bud itself suggests some relation to auxin which is synthesized in the apical bud. Since the phenomenon of the apical dominance has been described for the apical vegetative bud (20) and in peppers the apical vegetative bud is replaced by a floral bud, the same principle may be involved here also.

In 1960, the average height of the plant was not affected by the levels of nitrogen, as an independent factor, whereas in 1961, a linear

increase in the average plant height was obtained by raising the nitrogen level in the soil from 50 to 150 pounds per acre. This variation in the growth response between the two years results occured possibly because of the natural variation in the fertility of the two different fields. In 1960, the individual plots were found to have more variation in the nitrogen content of the soil as indicated by the data in Table 46 while in 1961 the initial soil samples showed more uniformity and little variation in the nitrogen content of the experimental plots (Table 48). The interactions of the treatments of deflowering or defruiting with the levels of nitrogen and calcium which caused average increase in the plant height resulted because the deflowered and defruited plants were probably able to absorb and utilize more nutrients from the soil than untreated plants.

Fruit Set

In the greenhouse and field tests, increase in the fruit set due to flower or fruit removal may be explained by the fact that the deflowered or defruited plants had more vegetative growth than the plants in which flowering or fruiting was permitted to occur naturally. The individual performances of the several varieties in their ability to produce fruits can be attributed to the genetical characteristics and their response to the existing environment. Differences in the yielding capacity of several pepper varieties have been reported by various workers (82, 111, 112, 123, 176, 177). In this investigation, the variety Yolo Wonder produced the highest total yield of all grades of peppers

followed by California Wonder and Florida Giant. The highest marketable early and late yields of fruits were also produced by the variety Yolo Wonder. However, the yields of peppers of all grades harvested from the variety California Wonder were greater than the variety Florida Giant. The variety Yolo Wonder produced U.S. Fancy fruits which were greater in average weight as compared to the fruits produced by Florida Giant and California Wonder. It was also found that in 1960 the tallest and more vigorous plants were obtained from the variety Yolo Wonder which helps explain the reason for the increased yield obtained with this variety. The deflowered plants of the variety Yolo Wonder produced larger yield in the later part of the season probably due to the increased vegetative growth while the other varieties did not response in growth to the same degree to the deflowering or defruiting treatment.

In the experiment of 1960, an increase in the level of nitrogen from 100 to 200 pounds per acre resulted in a linear reduction of U.S. Fancy fruits and total marketable yields. Three possible reasons are suggested for these results. There was a natural variation in the fertility of soil with regard to nitrogen; the higher fertilization rates of nitrogen may have resulted in an excessive vegetative growth which did not produce many flowers; and the highest rate of nitrogen may have caused abscission of flowers (31, 79, 107, 115). However, reduction in the yields of pepper fruits at high levels of nitrogen have been reported during the past years (100, 124).

The U.S. Fancy and total marketable yields were reduced by the raising of the nitrogen soil applications from 100 to 200 pounds per acre

regardless of whether the plants were deflowered, defruited or not treated. However, the late marketable yield was increased by removing the flowers after anthesis as compared to no removal treatment when nitrogen was added to the soil at the rate of 100 pounds per acre. Late yield was also increased at the nitrogen level of 200 pounds when the plants were defruited as compared to untreated plants. These increases in the late yield might have occured due to a greater absorption and utilization of nitrogen by deflowered and defruited plants. Also there were more reproductive centers formed as a result of deflowering or defruiting (11, 93, 117, 180).

The deflowering or defruiting treatments, as independent factors, did not influence the yield of pepper fruits in 1960 which may be attributed to the fact that there existed an interval of time in the removal of flowers or fruits from the plants. The treatment was made only once a week and only on those plants with flowers or fruits in the proper stage. This permitted other flowers or fruits to develop in the usual course during the week. Therefore, all the plants in the field did not receive the uniform treatment of deflowering or defruiting.

In the 1961 field experiment only one variety Yolo Wonder was used. The reason for using only the Yolo Wonder variety was that all the varieties responded similarly to the other treatments in 1960. It was also the highest yielder with the tallest plants and the late yield of peppers obtained from this variety was affected by the deflowering treatment.

The yields of grades U.S. Fancy, U.S. No. 1, total marketable and cull peppers were increased by removing the flowers or fruits. Similarly, the marketable early and late yields, and average weight of fruits per plant was significantly increased by the deflowering or defruiting treatment. This year the treatment was done in a more systematic way than 1960. The five flowers or fruits were consecutively removed from each plant during a 23-day period. No flower or fruit was allowed to pass by the stage at which it was intended to be removed. Therefore, the actual effects could be measured on all plants. The deflowered plants produced a greater number of fruits and bushels per acre of all grades of peppers than the defruited plants which indicates that the degree of inhibition by the flower bud may be more than the young developing fruits. These results are also supported by the data on the average plant height as found with the several treatments. Inhibition of fruit set by developing fruits and flowers have been reported in muskmelon (25), watermelon (26), cucumber (99) and tomato (87, 103, 106, 108, 173).

In comparison to the results obtained in 1960, the increase in the rates of nitrogen fertilization had the opposite effect on the yield of peppers in 1961. A linear increase in the yields of all grades was obtained as the levels of nitrogen were raised. Likewise, the marketable late yield and average weight of fruits per plant was obtained by increasing the level of nitrogen from 50 to 150 pounds per acre. The possible explanation for such results may be based on the following reasons: (1) a linear increase in the plant height was obtain ed by raising the rates of nitrogen application in the soil; (2) the rainfall

was more evenly distributed throughout the growing season which resulted in less leaching of the soil nitrogen; and (3) the individual plots were more uniform in natural soil fertility at the initiation of the experiment.

The increase of applied calcium, as an individual factor, did not have any effect on the yield of pepper fruits. However, interaction of the calcium levels with the deflowering or defruiting treatment was noted in several cases. When the calcium was applied at the rate of 500 pounds per acre, the yields of U.S. Fancy, U.S. No. 1, total marketable and cull peppers were increased by the removal of flowers or fruits. Similar increase was also found in the marketable late yield of peppers. This increase in yield may be due to increased absorption of soil nutrients at 500 pounds calcium level by the deflowered and defruited plants. Similar yields were not increased by the deflowering and defruiting treatments at 1,000 pounds calcium level probably because of unavailability to the roots for absorption (58, 67, 96).

In the 1961 experiment, the number of pepper fruits affected with blossom-end rot was reduced by increasing the calcium levels and the number was increased by raising the nitrogen levels. Similar responses on blossom-end rot, associated with nitrogen and calcium have been reported by Ozaki (131), Miller (100, 101), Geraldson (59, 60) and Ozaki and Ray (126). The effects of increasing the rates of nitrogen on decreasing the sunburn of peppers and the effect of removal of flowers or fruits on reducing the sunburn can be explained on the basis of greater vegetative growth. This limited the exposure of the fruits to

the sun. Similar effects of nitrogen fertilization on sunburn of peppers have been reported by Ozaki and Ray (126) and Ozaki, et al. (125).

Foliar Composition

Sugars.--In 1960, there was no effect of any treatment on the average content of reducing and total sugars in the pepper leaves which were sampled at the termination of the experiment. However, in 1961, several differences in both reducing and total sugars were found. The average reducing sugar content was increased by the removal of the flower buds or fruits. Since the removal of flowers or fruits produces a stimulus by which the vegetative growth is increased resulting in a greater photosynthetic area, more accumulation of sugars in the leaves could be expected. Heckel (69) found an increase in sucrose content when the female flowers in corn were removed with a little change in the reducing sugars. By removing the flower parts in sorghum he found an increase in the non-reducing sugars. McCollum (99) working with cucumber found that the fruiting plants were lower in polysaccharides and total sugars than the plants which had not started bearing fruits. He also found that a high carbohydrate content, especially reducing sugars, was always associated with the developing parts. He concluded that the increase in the reducing sugar in that part of the plant suggests that the fruit development was to some extent governed by this form of carbohydrate supply since fruits set more readily on the upper region of the stem.

The average content of reducing sugar in the leaves was also influenced by the interaction of the levels of nitrogen and calcium. The

plants, from the plots which did not receive any calcium application, showed a decrease in the reducing and total sugars in the leaves at the higher rates of nitrogen probably because of the conversion of nitrogen to the amino acids and amides. There was an increase in the total sugar content when the plants were defruited and calcium application was increased in the soil from 0 to 1,000 pounds per acre. It has been reported (77) that increasing the amount of calcium in the soil causes an improvement in the total carbohydrates, reducing and non-reducing sugars in the pepper leaves. However, the reason is not known. Two possible reasons perhaps may be furnished for the results obtained in the present investigation. First, it has been shown by fruiting responses that the application of calcium to the soil from 0 to 1,000 pounds per acre greatly decreased the yield of pepper fruits by the removal of fruits. Therefore, it may be possible that the increase in the sugar content in leaves resulted due to the decreased fruit yield. On the other hand a high amount of calcium might have caused a physical blocking in the translocation passage which did not allow the sugars to move from the leaves for the development of fruits. This latter explanation may account for the reduction of fruit yields at higher calcium levels. In fact, the role of calcium in the metabolism of carbohydrates is not known. However, the results of this investigation suggest further tests on sugars in order to make more definite conclusions.

Mineral Elements.--Increasing the rates of application of phosphorus in the soil of the pots in the greenhouse was found to raise the level

of phosphorus in the pepper leaves. Raising the rates of application of nitrogen made to the soil in the greenhouse pots, as well as in the field, resulted in an increase of the sodium content of the leaves because the source of nitrogen used was nitrate of soda. It frequently has been demonstrated that increasing the concentration of a given cation in the medium in which a plant is growing generally increases the quantity of that ion in the plant (6, 36, 68, 132). However, increasing the rates of potash applied to the soil of the pots decreased the amount of sodium in the leaves. Since both are monovalent ions a decrease in the sodium content could be expected as a result of competition. For some reason increasing the calcium levels increased the sodium content of the leaves. It has been known (17, 132) that calcium increases the uptake of potassium which indirectly might have increased the sodium in the leaves. Another possibility may be that if the available calcium in the soil is larger in quantity than the available sodium, the uptake of sodium by the plant is increased due to the effect of mass action (146).

The analysis of the leaves indicated that their average content of total nitrogen and potassium were not affected by several treatments in the field and greenhouse experiments of 1960. However, in the field experiment of 1961, raising the application of nitrogen made to the soil resulted in a linear increase of total nitrogen content in the tissue which may be expected. The leaf samples taken from deflowered plants showed a higher amount of nitrogen as compared to undeflowered plants. The possible reason for this increase can be explained on the

assumption that the deflowered plants were able to absorb more nitrogen from the soil (50, 159). This is also supported by the growth and fruiting responses as affected by deflowering treatment.

At the higher rates of nitrogen tested in the greenhouse, an increase in the amount of the potash applied resulted in a decrease in the content of magnesium in the leaves. This relationship of potassium and magnesium is well known (132, 146). In the field experiment of 1960, an interaction of the varieties and nitrogen levels occured with the magnesium and calcium content of the leaves. The nitrogen treatments above 150 pounds per acre decreased the magnesium content of the leaves of the variety Florida Giant. This may be attributed to the decrease in the growth of plants and the fruit yield. The interaction of variety and nitrogen on the calcium content of the leaves may have occured for the same reason. The different varieties probably had different capacities for absorbing the nutrients from the soil and differences in the growth and fruiting resulted in differential chemical composition of leaves. It may also be possible that calcium and magnesium, both being divalent ions, might have competed with each other.

In 1961, several complex interactions between treatments were found to have occured on the average content of the various elements in the leaves. The interaction of deflowering or defruiting with the levels of nitrogen and calcium occured on the average content of phosphorus, potassium, calcium and magnesium, in the pepper leaves. This may be attributed to the varying degrees of antagonism between

applied calcium and nitrogen when the level of either was changed along with the differential growth responses caused by deflowering or defruiting treatment.

When the application of calcium was raised from 0 to 1,000 pounds per acre, an increase in the average phosphorus content of the leaf samples was obtained with the nitrogen being applied to the plants at a low level (50 pounds per acre) when blossoms or young fruits were removed. It is well known that the application of calcium to the soil increases the uptake of phosphorus by the plant (77, 142, 146). Increasing the level of nitrogen resulted in a decreased content of phosphorus when no deflowering or defruiting treatment was made. This effect of nitrogen on the phosphorus content of the tissue can be expected (8, 29, 119, 132).

When flowers or fruits were removed from the plants the average potassium content of the leaf samples was decreased as the levels of applied nitrogen were raised in the substrate at 500 pounds level of calcium. Similar decrease in the potassium content was obtained by increasing the nitrogen levels from 50 to 150 pounds per acre to the deflowered plants when no calcium was applied. This effect of decreasing the average potassium content in the pepper leaves by increasing the levels of nitrogen may have occured due to a dilution factor induced by heavy vegetative growth and fruit set of pepper plants (29, 119).

An increase in the average calcium content of pepper leaf samples of plants growing at higher levels of calcium was obtained by increasing

the level of nitrogen application to the deflowered or defruited plants. The application of calcium sulfate and nitrate of soda in the same soil would result in the formation of calcium nitrate and sodium sulfate. Since nitrate is more soluble than the sulfate, the calcium would be absorbed along with the nitrate resulting in a greater amount of calcium and nitrogen in the leaves by raising the rate of nitrogen application to the soil (146).

A similar interaction was found on the average magnesium content of the leaves with increasing level of nitrogen to the deflowered or defruited plants of the pepper leaves which may be explained on the same basis as for calcium. Another possible reason seems to be associated with the relation of magnesium to chlorophyll of the leaves. The higher level of nitrogen and removal of flowers or fruits resulted in a dark green colored leaf due to greater production of chlorophyll whereas symptoms of chlorosis were apparent at low level (50 pounds per acre) of nitrogen. Therefore, it is assumed that the increase in magnesium content may be due to more amount of chlorophyll. On the other hand complementary influences have been reported by Nicholas (114) who found an improvement in the leaf magnesium as a result of increasing the amount of nitrogen in the fertilizer applied to tomato plants.

Data in this investigation do not provide logical explanation for the many interaction effects recorded in the results. The lack of an explanation for the interactions obtained does not indicate that such effects are unimportant but does indicate a need for more information

on the physiological and biochemical role of deflowering or defruiting and of various elements in plant metabolism.

Chemical Deflowering and Defruiting

The results of several greenhouse and field experiments begun in the Spring of 1960 indicated that hand deflowering or defruiting of the pepper plants increase the average plant height and fruit set to a considerable extent. This suggested the testing of some chemicals which could be used to remove the initial flowers or fruits of the pepper plants.

Among several chemicals tested, naphthaleneacetic acid, representing the auxin group, showed promise in removing the flowers from the pepper plants but did not increase the average plant height. The effective concentrations were 10^{-3} and 10^{-4} Molar which have been successfully used also to thin apple flowers (24, 94). The plants in the field seemed to be stunted and showed a chlorosis of leaves late in the season particularly at the higher concentrations above 10^{-4} Molar. Among the manifold roles of auxin which are more important are: inhibition of lateral bud growth, acceleration or inhibition of abscission, the stimulation of cambial growth and other meristematic activity, the inhibition and the promotion of non-osmotic water uptake (20). It is postulated that the flower bud might contain an auxin-like substance which inhibits the growth of the plant. By the application of higher concentration of a synthetic auxin (NAA for example), the flower abscission is promoted but the inhibition effect is possibly increased hence no growth response.

On the other hand, the application of gibberellic acid up to 10^{-2} Molar concentrations had a definite response on the growth of pepper plants but no effect on the abscission of flowers or fruits, a response similar to Biggs (18) and Addicott (2). No report is known which shows a positive response of the gibberellic acid on naturally occuring abscission of flowers and fruits.

Trans-cinnamic acid, representing the anti-auxin group, had an effect on increasing the plant growth but no flower abscission was noted. No literature is available for its use on abscission. However, the present investigation suggests that concentrations above 10^{-4} Molar should be tried because concentrations below 10^{-4} Molar had no effect on abscission and were not injurious to the plants.

The use of the gametocide, sodium 2,3-dichloroisobutyrate, was encouraging because the concentrations ranging from 0.05 per cent to 0.35 per cent did not have any injurious effect on the plants and the treated plants seemed to be more vigorous than the untreated plants. The effectiveness of concentration of 0.5 per cent on the plants of the guard rows in causing complete deflowering or defruiting was striking. This suggests that concentrations below 0.5 per cent and above 0.5 per cent should be tried in further testing.

The use of some other chemicals such as 2,3,5-triidobenzoic acid and some oils and cresols may prove useful additions in future research work in this regard (86, 171).

SUMMARY AND CONCLUSIONS

Several experiments were conducted in the field, as well as in the greenhouse to test the effect of different varieties, various treatments of deflowering and defruiting and levels of nitrogen and calcium fertilization on the growth, fruit set, quality of fruits and foliar composition of Bell peppers (Capsicum annum L.) during the years 1960 and 1961.

In the greenhouse experiments, the variety Early Calwonder produced taller plants as compared to the varieties Yolo Wonder, Florida Giant and California Wonder. Increasing the level of nitrogen from 100 to 200 pounds per acre did not have any significant effect on the average plant height. The variety Yolo Wonder was most responsive in height increase by raising the nitrogen level from 100 to 150 pounds per acre. Raising the potash level from 100 to 200 pounds per acre also resulted in a greater height of the plants of the variety Yolo Wonder. The removal of young flower buds resulted in the production of the tallest plants with the largest number of fruits followed by the response resulting from the removal of young developing fruits. None of the treatments affected the average stem diameter of the pepper plants.

The field experiment in 1960 involved the testing of three varieties (Florida Giant, Yolo Wonder and California Wonder), three treatments of deflowering or defruiting (untreated, flowers removed after anthesis,

and removal of young developing fruits) and three levels of nitrogen (100, 150 and 200 pounds per acre). Results indicated that taller plants were produced by the variety Yolo Wonder in comparison to plants of Florida Giant and California Wonder. The removal of flowers or young fruits increased average plant height significantly as compared to untreated plants but had no effect on the fruit set. When the plants were deflowered or defruited, the average yield as measured by number and bushels per acre of U.S. Fancy and total marketable pepper fruits was decreased by raising the level of nitrogen from 100 to 200 pounds per acre. However, the deflowering treatments resulted in the increased yield of marketable fruits harvested in the later part of the season at 100 pounds nitrogen level. The variety Yolo Wonder produced the highest yield of U.S. Fancy, U.S. No. 1 and total marketable fruits. Early and late marketable yields of peppers, as separated by the time of harvests, were larger for the variety Yolo Wonder. The variety Yolo Wonder produced a larger late yield when the plants were deflowered or defruited. A heavier average pepper fruit of U.S. No. 1 grade was produced by raising the nitrogen levels and removing the flowers after anthesis.

The treatments in the field experiment of 1961 consisted of three deflowering or defruiting treatments (untreated, removal of flower buds before anthesis and removal of young developing fruits), three levels of nitrogen (50, 100 and 150 pounds per acre), and three levels of calcium as gypsum (0, 500 and 1,000 pounds per acre). The deflowering or

defruiting treatments had a marked increase on the average plant height, in the yield of fruits of all grades, the production of early and late marketable yields, and average weight of marketable fruits per plant. A linear increase in each of the aforementioned growth or production measurements resulted as the levels of nitrogen were raised from 50 to 150 pounds per acre. An application of calcium from 0 to 500 pounds per acre decreased the average height of the pepper plants with an increase at 1,000 pounds level when no flowers or fruits were removed. When the plants were deflowered, the height was increased by raising the calcium application from 0 to 1,000 pounds per acre. Calcium, as an individual factor, did not have any effect on the yield of peppers. However, when flowers or fruits were removed from the plant, the addition of calcium in the soil increased the yield of all grades and average weight of marketable fruits per plant. The late yield, consisting of the last three pickings from deflowered or defruited plants, was increased at the 500 pounds level of calcium by increasing the rate of nitrogen fertilizer application from 50 to 150 pounds per acre.

An increase in the rate of nitrogen fertilizer resulted in an increased number of fruits with blossom-end rot and a reduced number of sunburned fruits. On the other hand, increasing the rate of application of calcium significantly decreased blossom-end rot. Removal of flowers or fruits reduced the number of sunburned fruits but did not have any effect on the number of fruits with blossom-end rot.

The analysis of leaf samples from plants growing in the greenhouse experiment showed that increasing the level of soil phosphorus resulted

in a greater amount of phosphorus in the tissue. The addition of potash to the pots from 100 to 200 pounds per acre decreased the percentage of magnesium in the leaves. Sodium content of the leaves was increased by raising the nitrogen levels from 50 to 150 pounds per acre using nitrate of soda as a source for nitrogen side-dressings. Similarly, the calcium content of the leaves was increased by raising the phosphorus level in the pots.

The leaf analysis of the samples obtained from the field experiment in 1960 did not show any differences in the average content of reducing sugar, total sugar, total nitrogen, phosphorus and potassium. However, a significant decrease in the magnesium content was obtained in the leaves of the variety Florida Giant when the nitrogen fertilization levels were raised above 150 pounds per acre. On the other hand, nitrogen rates below 150 pounds increased the amount of calcium in the leaves. In general, deflowering or defruiting treatment increased the average amount of calcium in the leaf tissue.

In 1961, the average level of the reducing and total sugars, as found in the leaf samples, was increased by removing the flowers or young fruits from the plant at the lower level of nitrogen fertilization. At the higher levels of nitrogen fertilization, the average level of reducing sugars and total sugars were reduced. A decrease in the average sugar content also was obtained by raising the calcium level in the soil. Increases in the level of nitrogen fertilization resulted in a higher level of total nitrogen being found in the leaf tissue. The

removal of flowers or young fruits increased the average total nitrogen level in the leaves at the end of the growing season. The average phosphorus, potassium, calcium and magnesium contents of the leaves were affected by the interaction of deflowering or defruiting with nitrogen and calcium levels. In general, increasing the rates of calcium applied to the soil increased the amount of calcium, phosphorus, magnesium and sodium found in the leaves. Raising the level of nitrogen through fertilization resulted in a decrease of the average potassium and phosphorus contents and an increase in calcium, magnesium and sodium found in leaves.

Four chemicals, namely naphthaleneacetic acid, gibberellic acid, trans-cinnamic acid and sodium 2,3-dichloroisobutyrate, were tested for their potentiality to induce abscission of flower or fruits and the subsequent growth and fruiting of peppers. Naphthaleneacetic acid had a marked effect on the abscission of flowers and yields of U.S. Fancy pepper fruits but did not influence the average plant height. Gibberellic acid and trans-cinnamic acid had no effect on abscission and yield of peppers but increased the plant height to a considerable extent. Sodium 2,3-dichloroisobutyrate was effective in inducing the abscission but had no effect on the plant height and yield of peppers.

It is believed that the findings of this investigation would assist in solving some of the cultural problems related to this important crop. The deflowering or defruiting treatment would make possible the production of moderate sized plants prior to continuous blooming and subsequent

fruit setting which would result in increasing the average yield. The results obtained with the levels of nitrogen and calcium fertilization would suggest better improvement in the soil fertility for optimum pepper yields on sandy soils. The results on the blossom-end rot of pepper fruits have further confirmed its relationship with calcium and nitrogen availability. The treatment of deflowering and defruiting and levels of nitrogen used would also help improve the quality by reducing the number of sunburned fruits. Preliminary work on the chemical removal of flowers or fruits would indicate that further research along these lines would be profitable.

APPENDIX

TABLE 46

THE AVERAGE PER CENT TOTAL NITROGEN AND POUNDS PER ACRE OF AVAILABLE P_2O_5 AND K_2O IN THE SOIL SAMPLES TAKEN FROM THE PEPPER BEDS--1960

Treatment	N		P_2O_5		K_2O	
	Initial	Final	Initial	Final	Initial	Final
V0 D0 N0	0.109	0.064	38	48	190	137
V0 D0 N1	0.077	0.088	42	47	178	134
V0 D0 N2	0.057	0.088	47	73	167	135
V0 D1 N0	0.098	0.077	48	70	181	218
V0 D1 N1	0.084	0.074	43	65	200	203
V0 D1 N2	0.063	0.063	36	45	183	130
V0 D2 N0	0.063	0.067	45	84	208	240
V0 D2 N1	0.077	0.074	40	46	194	146
V0 D2 N2	0.077	0.071	49	77	192	197
V1 D0 N0	0.088	0.102	53	62	208	190
V1 D0 N1	0.053	0.085	38	48	189	147
V1 D0 N2	0.077	0.056	42	60	196	135
V1 D1 N0	0.074	0.088	43	48	172	135
V1 D1 N1	0.098	0.070	41	50	198	171
V1 D1 N2	0.074	0.074	47	75	176	154
V1 D2 N0	0.067	0.063	37	43	168	124
V1 D2 N1	0.079	0.064	51	86	160	161
V1 D2 N2	0.091	0.059	41	55	191	149
V2 D0 N0	0.067	0.070	39	59	187	162
V2 D0 N1	0.091	0.098	42	65	203	162
V2 D0 N2	0.095	0.070	50	64	170	115
V2 D1 N0	0.085	0.085	41	56	206	148
V2 D1 N1	0.081	0.085	43	57	165	132
V2 D1 N2	0.064	0.064	47	61	181	144
V2 D2 N0	0.091	0.077	54	88	160	164
V2 D2 N1	0.091	0.081	46	55	191	130
V2 D2 N2	0.056	0.070	43	48	195	153

Variety	Deflowering or defruiting	Nitrogen
V0 = Florida Giant	D0 = Normal field	N0 = 100 lbs/Acre
V1 = Yolo Wonder	D1 = Flowers removed	N1 = 150 lbs/Acre
V2 = California Wonder	D2 = Young developing fruits removed	N2 = 200 lbs/Acre

TABLE 47

THE AVERAGE pH AND THE POUNDS PER ACRE OF AVAILABLE CAO AND MGO IN THE SOIL SAMPLE TAKEN FROM THE PEPPER BEDS--1960

Treatment	pH		CaO		MgO	
	Initial	Final	Initial	Final	Initial	Final
V0 D0 N0	6.0	6.0	984	1,042	128	133
V0 D0 N1	6.1	6.0	1,233	1,125	140	141
V0 D0 N2	6.2	6.0	1,457	1,328	136	167
V0 D1 N0	6.2	5.8	1,357	1,309	160	193
V0 D1 N1	6.1	5.9	1,267	1,308	144	185
V0 D1 N2	6.0	6.0	914	744	194	109
V0 D2 N0	6.2	5.8	1,379	1,473	163	195
V0 D2 N1	6.1	6.1	1,209	1,162	132	140
V0 D2 N2	6.1	5.9	1,330	1,354	177	210
V1 D0 N0	6.5	6.1	1,645	1,440	138	192
V1 D0 N1	6.0	5.9	1,214	963	133	135
V1 D0 N2	6.1	6.0	1,220	1,249	150	147
V1 D1 N0	6.1	6.0	1,136	1,119	133	145
V1 D1 N1	6.1	5.9	1,125	1,069	121	156
V1 D1 N2	6.2	6.0	1,282	1,247	123	167
V1 D2 N0	6.0	6.0	1,084	1,052	125	127
V1 D2 N1	6.2	5.9	1,361	1,380	158	163
V1 D2 N2	6.1	6.1	1,268	1,150	153	147
V2 D0 N0	6.0	5.8	1,030	1,154	123	145
V2 D0 N1	6.1	6.0	1,322	1,435	164	132
V2 D0 N2	6.1	6.1	1,105	1,226	136	138
V2 D1 N0	6.2	6.0	1,326	1,534	176	147
V2 D1 N1	6.2	6.0	1,936	1,242	142	138
V2 D1 N2	6.2	6.1	1,409	1,399	157	159
V2 D2 N0	6.2	5.9	1,369	1,659	123	169
V2 D2 N1	6.2	6.0	1,202	1,199	140	135
V2 D2 N2	6.1	5.9	1,154	1,131	155	153

Variety	Deflowering or defruiting	Nitrogen
V0 = Florida Giant	D0 = Normal field	N0 = 100 lbs/Acre
V1 = Yolo Wonder	D1 = Flowers removed	N1 = 150 lbs/Acre
V2 = California Wonder	D2 = Young developing fruits removed	N2 = 200 lbs/Acre

TABLE 48

THE AVERAGE PER CENT TOTAL NITROGEN AND POUNDS PER ACRE OF AVAILABLE P_2O_5 IN SOIL SAMPLE TAKEN FROM THE PEPPER BEDS--1961

Treatment	N			P_2O_5		
	Initial	Interim	Final	Initial	Interim	Final
D0 N0 C0	0.043	0.033	0.035	47	43	91
D0 N0 C1	0.036	0.046	0.028	43	39	60
D0 N0 C2	0.039	0.046	0.035	51	41	35
D0 N1 C0	0.036	0.039	0.033	40	42	79
D0 N1 C1	0.033	0.029	0.023	45	77	77
D0 N1 C2	0.053	0.029	0.028	41	39	44
D0 N2 C0	0.033	0.033	0.029	44	51	72
D0 N2 C1	0.036	0.049	0.040	42	77	111
D0 N2 C2	0.046	0.039	0.035	43	43	65
D1 N0 C0	0.036	0.036	0.020	43	41	63
D1 N0 C1	0.029	0.023	0.020	41	62	229
D1 N0 C2	0.043	0.033	0.045	42	42	39
D1 N1 C0	0.036	0.036	0.048	44	38	99
D1 N1 C1	0.033	0.043	0.028	43	43	40
D1 N1 C2	0.039	0.039	0.038	41	48	147
D1 N2 C0	0.039	0.046	0.040	43	39	57
D1 N2 C1	0.046	0.046	0.045	40	40	84
D1 N2 C2	0.033	0.036	0.028	43	47	158
D2 N0 C0	0.036	0.052	0.030	42	51	94
D2 N0 C1	0.042	0.046	0.045	45	43	61
D2 N0 C2	0.036	0.036	0.033	42	52	42
D2 N1 C0	0.036	0.053	0.050	39	41	102
D2 N1 C1	0.033	0.049	0.040	43	39	91
D2 N1 C2	0.042	0.053	0.035	39	42	41
D2 N2 C0	0.053	0.043	0.050	40	39	132
D2 N2 C1	0.036	0.049	0.028	44	61	118
D2 N2 C2	0.046	0.046	0.043	43	45	88

Deflowering or defruiting	Nitrogen	Calcium sulfate
D0 = Normal yield	N0 = 50 lbs/Acre	C0 = No Calcium sulfate
D1 = Flower buds removed	N1 = 100 lbs/Acre	C1 = 500 lbs/Acre
D2 = Young developing fruits removed	N2 = 150 lbs/Acre	C2 = 1,000 lbs/Acre

TABLE 49

THE AVERAGE POUNDS PER ACRE OF AVAILABLE K_2O AND MGO IN THE SOIL SAMPLE TAKEN FROM THE PEPPER BEDS--1961

Treatment	K_2O			MgO		
	Initial	Interim	Final	Initial	Interim	Final
D0 N0 C0	90	58	100	42	37	47
D0 N0 C1	93	56	75	45	39	47
D0 N0 C2	102	68	34	54	57	43
D0 N1 C0	101	77	79	44	54	64
D0 N1 C1	79	80	89	37	49	45
D0 N1 C2	85	55	66	44	45	40
D0 N2 C0	88	63	72	44	46	49
D0 N2 C1	94	78	82	53	56	53
D0 N2 C2	93	65	82	45	39	42
D1 N0 C0	117	52	97	44	39	58
D1 N0 C1	93	63	148	44	39	83
D1 N0 C2	98	61	56	56	48	39
D1 N1 C0	81	46	111	51	44	65
D1 N1 C1	103	67	49	45	52	38
D1 N1 C2	99	64	108	55	45	49
D1 N2 C0	91	62	83	63	46	41
D1 N2 C1	101	72	84	57	54	62
D1 N2 C2	69	44	107	39	32	57
D2 N0 C0	78	50	115	37	32	58
D2 N0 C1	75	54	67	44	39	44
D2 N0 C2	90	60	69	51	55	46
D2 N1 C0	76	58	98	40	35	49
D2 N1 C1	104	48	76	44	32	50
D2 N1 C2	86	67	70	48	58	48
D2 N2 C0	102	60	69	59	50	76
D2 N2 C1	86	73	109	52	51	66
D2 N2 C2	79	46	96	37	33	50

Deflowering or defruiting

D0 = Normal field
D1 = Flower buds removed
D2 = Young developing fruits removed

Nitrogen

N0 = 50 lbs/Acre
N1 = 100 lbs/Acre
N2 = 150 lbs/Acre

Calcium sulfate

C0 = no Calcium sulfate
C1 = 500 lbs/Acre
C2 = 1,000 lbs/Acre

TABLE 50

THE AVERAGE pH AND POUNDS PER ACRE OF AVAILABLE CAO IN THE SOIL SAMPLE TAKEN FROM THE PEPPER BEDS--1961

Treatment	pH			CaO		
	Initial	Interim	Final	Initial	Interim	Final
D0 N0 C0	5.9	6.0	5.5	367	420	621
D0 N0 C1	5.9	5.9	5.5	367	367	414
D0 N0 C2	6.0	5.8	5.7	388	661	1,302
D0 N1 C0	6.0	5.9	5.8	420	461	778
D0 N1 C1	5.9	5.9	5.3	294	570	753
D0 N1 C2	6.0	6.0	5.5	399	420	732
D0 N2 C0	5.9	6.0	5.7	347	367	352
D0 N2 C1	6.0	5.7	5.9	490	742	664
D0 N2 C2	5.9	6.0	5.4	367	346	1,464
D1 N0 C0	5.7	6.0	5.6	350	294	530
D1 N0 C1	5.9	6.0	5.4	361	420	1,303
D1 N0 C2	6.0	6.1	5.7	546	542	452
D1 N1 C0	6.0	6.2	5.5	430	409	537
D1 N1 C1	5.9	6.2	5.7	357	389	445
D1 N1 C2	5.9	6.1	5.4	441	661	1,157
D1 N2 C0	6.0	6.0	5.9	568	588	523
D1 N2 C1	6.0	6.2	5.6	560	538	1,144
D1 N2 C2	5.8	6.1	5.3	325	304	1,250
D2 N0 C0	5.7	5.8	5.3	315	294	467
D2 N0 C1	5.8	5.9	5.4	346	346	1,130
D2 N0 C2	5.9	5.8	5.2	439	526	908
D2 N1 C0	5.9	6.0	5.4	336	336	606
D2 N1 C1	5.8	6.1	5.4	357	315	547
D2 N1 C2	6.1	6.2	5.7	337	514	1,007
D2 N2 C0	5.7	6.2	5.6	518	511	915
D2 N2 C1	6.0	6.0	5.6	535	628	1,288
D2 N2 C2	5.8	5.9	5.3	294	382	563

Deflowering or defruiting

D0 = Normal field
D1 = Flower buds removed
D2 = Young developing fruits removed

Nitrogen

N0 = 50 lbs/Acre
N1 = 100 lbs/Acre
N2 = 150 lbs/Acre

Calcium sulfate

C0 = No Calcium sulfate
C1 = 500 lbs/Acre
C2 = 1,000 lbs/Acre

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BIOGRAPHICAL SKETCH

Kirti Singh was born on May 26, 1934 in a village named Basgit of District Jaunpur, State of Uttar Pradesh, India. After his graduation from Junior High School in 1948, he took his high school education at Central Hindu School Banaras (now Varanasi) administered by Banaras Hindu University and was graduated in 1951.

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This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Agriculture and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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